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THE DARK SIDE OF LEAN OPERATIONS: JUST-in-TIME, INVENTORY REDUCTION AND SUPPLY CHAIN VULNERABILITY

Individual Report – Critical Literature Review

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ABSTRACT

This report explores the dark side of lean operations by examining how just-in-time (JIT) and inventory reduction can create vulnerabilities in supply chains. It is based on a focused review of recent academic journal articles on lean production, supply chain risk and resilience. The review shows that lean and JIT can reduce waste, improve quality and shorten lead times. But it can also increase exposure to disruptions when inventory, capacity and supplier bases are pushed to very lean levels. Studies also show social risks, such as work intensification and stress, when lean is used by completely focusing on cost cutting. The report brings together this work with research on supply chain resilience, which points to the role of targeted redundancy, flexibility and better visibility. It concludes that companies should combine lean principles with selected buffers and risk management practices in order to balance efficiency and resilience.

TABLE OF CONTENTS

Table of Contents

1 INTRODUCTION

In today's globalized and highly competitive business environment, many organizations face constant pressure to improve efficiency, reduce costs and also deliver products and services faster. As a result, today's operations management is placing strong emphasis on lean practices, including just-in-time (JIT) production and aggressive reduction of inventory. The main aims of these approaches are to eliminate waste, smoother process flow and also to free up working capital. Many organizations after using these practices have noticed improvements in quality, production and overall operational performance.

Despite all of these, recent years have shown a different side to this story. Global supply chains have been affected by various events such as pandemics, natural disasters, geopolitical tensions and logistics bottlenecks. In many such situations, companies that pursued lean, tight coupled operations were more vulnerable to shocks. Low inventory levels, single sourcing and high capacity utilization, while efficient under stable conditions, will leave only little room to absorb delays, demand spikes or interruptions in supply. As a result of all this, the same lean practices that once appeared to be a clear competitive advantage have been criticized for contributing to fragility and risk.

This report examines the dark side of lean operations, by focusing particularly on how JIT and inventory reductions can increase supply chain vulnerability in a volatile world. The central question that'll guide this review is:

"How do lean operations practices, especially just-in-time inventory and inventory reduction, create vulnerabilities in supply chains and what strategies does recent research propose to balance efficiency with resilience?"

In order to answer this question, the report will undertake a critical review of recent academic literature published within the last ten years. This discussion will begin with an overview of key concepts in lean operations, JIT and supply chain risk and resilience. It then explains how the literature describes the mechanisms through which lean practices can generate operational and social vulnerabilities. After that, the review will explore the strategies put forward by the researchers to get back the lean efficiency with supply chain resilience. Finally, the report will combine the main themes, identify gaps in the existing research and list out the practical implications for operations managers that are looking to design more robust and sustainable operations systems.

2 CONCEPTUAL BACKGROUND

2.1 LEAN OPERATIONS AND JUST-IN-TIME

Lean operations is a method of managing processes that aims to deliver maximum value to the customer using minimum amount of resources. It focusses on the elimination of waste, making processes smoother and the continuous improvement of activities across the value chain (Antony et al, 2021). Common lean practices include standardized work, visual management, rapid changeovers, small lot sizes and close coordination with suppliers and customers. These are used to reduce cost, improve quality and shorten lead times. Various systematic reviews show that, in stable environments, lean implementation is strongly associated with better operational performance such as lower lead times and reduced defect rates (Antony et al, 2021; Fogliatto et al, 2024),

Within lean operation, just-in-time (JIT) production is one of the core practices. JIT aims to match material flows with actual demand, so that items are produced or delivered only when they are needed and in the required quantity. This'll reduce inventories of raw materials, work in process and finished goods (Habibi Rad et al, 2021). Inventory reduction is not only a cost saving measure, but it also used to expose the underlying problems with the processes that might otherwise be hidden by large buffers. When inventory is kept low, various issues such as unreliable suppliers or process instability becomes visible. This can encourage the planners to solve the root cause problems and also to improve continuously (Antony et al, 2021).

2.2 SUPPLY CHAIN RISK AND RESILIENCE

When the term 'supply chain risk' or related terms are used, it is referring to the likelihood and impact of the events that'll disrupt the normal flow of materials, information or funds in a supply network. Common sources are things like supplier failures, transport delays, demand shocks, pandemics and natural disasters (Li et al, 2020; Dolgui et al, 2021). Recent research on the "ripple effect" shows that disruptions at one node can spread through multiple levels of a supply chain, which'll increase the overall impact on performance and recovery time (Dolgui et al, 2021).

In this context, supply chain resilience is normally defined as the capability of a supply chain to prepare for unexpected events, respond effectively to disruptions and return to a desired performance level within an accepted time frame (Li et al, 2020; Guo et al, 2025). The literature shows several mechanisms that support resilience, including redundancy (e.g. safety stock or backup suppliers), flexibility (ability to change routes, modes or capacity) and improved visibility across the network (Aldrighetti et al, 2021; Guo et al,

2025). Inventory policies and positioning are important to these mechanisms because they determine how shocks are absorbed or spread along the chain (Guo et al, 2025).

2.3 THE ‘DARK SIDE’ OF LEAN

Although usually lean is shown as a positive, efficiency improving approach, recent studies shows a possible “dark side”. Salentjin et al. (2021) show that lean programs can contribute to work intensification and stress when cost reduction is prioritized over employee well being. From an operational side, lean and JIT practices such as minimal inventory, high capacity utilization and close supplier integration can also reduce the buffers and options that’ll help organizations manage disruptions. Various real world experiences and modelling studies show that highly lean supply chains may experience bigger performance losses and will have longer recovery times when disruptions happen, especially in global, multi tier networks (Li et al, 2020; Dolgui et al, 2021; Guo et al, 2025). On the other hand, integrative reviews argue that lean and resilience can coexist if lean practices are combined with targeted redundancy and flexibility (Habibi Rad et al, 2021).

This report will be built on these information by looking at how lean and JIT practices can increase vulnerability and how recent research proposes to balance lean efficiency with supply chain resilience.

3 METHOD FOR LITERATURE REVIEW

This report is based on a focused review of academic journal articles that discusses lean operations, just-in-time (JIT) inventory practices and supply chain resilience. Articels were searched using online databases such as Google Scholar and university library resources. The main keywords used in different combinations are “lean operations”, “lean production”, “just-in-time”, inventory reduction”, “supply chain risk”, “supply chain resilience” and “disruptions”.

To keep the review recent and relevant, the search was mainly limited to articles published in the last ten years and only peer reviewed journal papers written in English were included. Articles were selected if they focused on either:

- The effects of lean or JIT on operations or workers, or
- How supply chain can stay resilient while using low inventory and tight process flows.

From this process, a set of around eight core journal articles were chosen, including review papers, case studies and modelling studies. These articles are the main base for this discussion and analysis in the rest of the report.

4 THE DARK SIDE OF LEAN: HOW LEAN AND JIT CAN INCREASE VULNERABILITY

4.1 LEAN AND JIT IN THEORY: WHY THEY LOOK SO ATTRACTIVE

From a theoretical standpoint, lean and JIT promise many benefits. The lean method aims to cut waste, improve flow and increase quality. JIT aims to produce or deliver items only when they are needed, so that inventory is kept very low. Review papers show that, in many companies, lean has helped to reduce lead times, cut costs and improve quality and delivery performance (Antony et al, 2021; Fogliatto et al, 2024). Because of these benefits, many companies have tried to become as lean as possible. They reduce safety stock, work with only few suppliers and try to keep machines and workers busy most of the time. Under normal, stable conditions, this can work very well and make the company more competitive. But these same choices can also create hidden risks when the environment is uncertain or when large disruptions happen.

4.2 LOW INVENTORY AND TIGHT COUPLING: WHEN STRENGTH BECOMES WEAKNESS

One common feature of lean and JIT is low inventory. This means there's less safety stock at different points in the supply chain. Another feature is tight coupling between steps in the process. Materials arrive just before they are needed and production often runs close to full capacity. Studies on supply chain risk show that, when buffers are small and processes are tightly linked, disruptions can spread more easily along the chain (Li et al, 2020; Dolgui et al, 2021). For example, if a key supplier has a delay, a lean customer has very little stock to keep the production going. This can cause the entire line to stop and the problem can then move on to the next stage and even to the customer. Dolgui et al. (2021) describes this phenomenon as a "ripple effect", where a shock at one point creates larger and larger effects at other points in the network.

Guo et al. (2025) review research on inventory and resilience. That study argues that inventory is not just a cost, but also a form of protection. When companies push inventory

too low in the name of lean, they may lose this protection. In normal conditions, low stock improves financial performance. But during crises, it can make the impact much worse because there is nothing to absorb the shock.

In short, lean and JIT can create a tradeoff. They improve efficiency in normal times but may reduce the ability to face unexpected events.

4.3 SOCIAL AND HUMAN COSTS: WORK INTENSIFICATION AND PRESSURE

The dark side of lean is not only about disruption and inventory. It also appears in how the work is organized and how people experience their jobs. Salentijn et al. (2021) carried out a systematic review of studies on lean and social outcomes. They found that, while lean can support learning and problem solving, it is often linked to work intensification, time pressure and stress when it is used mainly as a cost cutting tool.

Distelhorst et al. (2017) studied lean in the case of Nike's global supply chain. They found that lean can improve some labor standards when combined with strong management and monitoring systems. But they also showed that if there is pressure for higher output without enough support, lean practices like line balancing and takt time can increase the strain on workers.

Considering everything, these studies suggest that the impact of lean on people isn't always positive. It depends on how the system is designed and what the main goal is. When lean is mainly used to do a lot of work with less resources and to keep people and machines busy at all times, the result can be higher stress, less job control and more health and safety risks. And these tired or stressed workers who are more likely to make mistakes, can end up causing operational risk.

4.4 WHEN LEAN WORKS AND WHEN IT BECOMES RISKY

The literature also shows that the effects of lean and JIT strongly depends on the context. Fogliatto et al. (2024) studies the Brazilian automotive supply chain and show that lean practices can support resilience if they reduce variability and improve coordination with suppliers. In stable conditions, lean tools such as standardization, visual control and problem solving routines can help firms respond faster and recover more quickly from small disruptions.

On the other hand, Li et al. (2020) and Guo et al. (2025) highlight that, in networks with long lead times, many tiers and strong exposure to global risks, very lean inventory methods can make things worse during large shocks. In such cases, low stock levels,

single sourcing and high utilization leave little room to react to demand increases or supply failures. The same lean methods that look effective in normal conditions may be dangerous in a volatile situation. This means that lean and JIT are not good or bad by themselves. But their impact depends on:

- How far companies push inventory reduction
- How complex and global their supply chain are
- Whether they have measures in place to handle risk

4.5 SUMMARY OF THE DARK SIDE

a. **Higher exposure to disruptions**
   Low inventory and tight coupling can increase effect of shocks and slow recovery (Li at al. 2020; Dolgui et al. 2021; Guo et al. 2025).

b. **Social and human risks**
   In some cases, lean leads to work intensification, stress and pressure on workers and suppliers, especially when focusing on cost reduction (Salentijn et al. 2021; Distelhorst et al. 2017).

c. **Strong dependance on context**
   Under normal conditions, lean can support resilience, but in volatile conditions it can be fragile (Fogliatto et al. 2024; Habibi Rad et al. 2021).

5 BALANCING EFFICIENCY AND RESILIENCE: SOLUTIONS IN THE LITERATURE

The papers reviewed does not say that companies should stop using lean or JIT. Instead, they tell that lean needs to be supported by other measures so that operations stay both efficient and resilient. The question is not, lean or resilience, but how to design lean systems that can still cope with shocks.

Several authors argue that if some protection measures are taken, then lean practices can support resilience when they reduce waste and improve process stability (Habibi Rad et al. 2021; Fogliatto et al. 2024). Lean tools such as standard work, clear process flow and problem solving routines can help companies react more quickly when something goes wrong. But also, companies need small buffers and backup options so that disruptions does not affect the whole chain.

A common suggestion is to use smart redundancy. Rather than holding large amounts of inventory everywhere, companies can keep safety stock for important items or at important points in the network they can use backup suppliers or routes for high risk materials (Aldrighetti et al. 2021; Guo et al. 2025).

Another suggestion is related to flexibility and visibility. Li et al. (2020) and Dolgui et al. (2021) show that disruptions spread quickly in complex networks when there is little information and fewer options to reroute flows. To reduce this, companies can share information more closely with suppliers and customers, use tracking systems to see where goods are in real time and design processes that can switch between products, routes or modes of transport when needed.

Considering everything, the literature suggests that companies can keep the main ideas of lean such as waste reduction and flow, while adding limited redundancy, flexibility and visibility to avoid becoming too fragile.

6 SYNTHESIS AND RESEARCH GAPS

The literature reviewed in this report shows a mixed picture of lean and JIT. On one side, lean helps companies reduce waste, improve quality and reduce lead times, especially in normal conditions (Antony et al. 2021; Fogliatto et al. 2024). But on the other side, the same features that makes lean attractive, can increase exposure to disruptions and also put extra strain on workers (Salentijn et al. 2021; Distelhorst et al. 2017). In short, lean is not good or bad by itself, but its impact depends on its design and in the context.

The research on resilience gives a partial solution. Work by Li et al. (2020), Dolgui et al. (2021), Habibi et al. (2021) and others shows that limited redundancy, flexibility and better visibility can be added to lean systems to reduce their fragility. But, there are several gaps. Most studies focus on large manufacturing firms, with less attention to services or smaller companies. Also there is little evidence on long term effects or on how managers should decide the right amount of slack in different environments. These gaps open opportunities for further research on lean in more diverse contexts and on simple tools that’ll be used to help managers balance efficiency and resilience.

7 MANAGERIAL IMPLICATIONS OF OPERATIONS MANAGERS

The literature on the dark side of lean suggests that operations managers should be careful about how far they push lean and JIT, especially in uncertain conditions. First, managers should avoid treating inventory just as a cost. Small, well placed buffers can protect the supply chain from major disruption, especially for critical items (Aldrighetti et al. 2021; Guo et al. 2025). Instead of removing all safety stock, managers can keep limited extra stock at key points while still using lean tools to reduce waste.

Second, managers should build flexibility and visibility into lean systems by developing backup suppliers for important materials, designing processes that can change between products or routes and improving information sharing with key partners (Li et al. 2020; Dolgui et al. 2021).

At last, the social side of lean should not be ignored. Evidence shows that lean can increase work pressure and stress. Managers should involve employees in improvement activities, monitor workload and keep performance targets realistic (Salentijn et al. 2021; Distelhorst et al. 2017). In the long run, a lean system that supports people as well as performance is more likely to remain stable and resilient.

8 CONCLUSION

This report has examined the dark side of lean operations. There was focus on how just-in-time (JIT) and inventory reduction can increase supply chain vulnerability. The literature shows that lean and JIT can deliver clear benefits in terms of cost, quality and speed especially in stable conditions. But, low inventory, tight process links and strong cost pressures can make companies more exposed to disruptions and can create higher stress for workers and suppliers.

Recent research suggests that companies do not need to reject lean, but they should support it with limited redundancy, flexibility and better visibility in the supply chain. The overall message is that lean systems need to be designed with risk in mind. When efficiency and resilience are planned together, operations are more likely to be both competitive and robust.

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