WHITE PAPER

Does Supply Chain Resilience Demand Alternatives to Lean?

Alternative strategies and buffers are needed to prevent famished and fragile supply chains

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The shocks over the past several years (including a tsunami, volcano, container ship stuck in the Suez Canal, the war in Ukraine, and the COVID-19 pandemic) have wreaked havoc in supply chains—especially those that are extended around large parts of the globe. Political unrest, environmental issues, and economic uncertainty test the resilience of manufacturing operations, especially for supply chains that are extended across much of the globe.

In this environment, the phrase "too much of a good thing" might hold true with making operations leaner. Lean manufacturing, often held to be conceptually equivalent to "efficiency," is a solid strategy for situations with low variation and high predictability. But in our environment today – one that combines high levels of unpredictability with geographic spread – how does the concept of Lean (with a capital "L") compare to alternative manufacturing strategies to keep disruptions low and output high?

The key is to recognize that alternatives to Lean exist. Resilience often requires some "fat" to run smoothly. "Sometimes the supply chain needs to eat a little bit of 'butter' in the form of a capacity buffer or safety stock," says Suzanne de Treville, emeritus professor of operations management at the University of Lausanne and co-editor-in-chief of the Journal of Operations Management (JOM), an ASCM owned journal. Some Lean proponents claim that because adding this buffer increases resilience and hence performance, the buffer—getting fatter—takes the process toward Lean. The editors-in-chief of the JOM do not agree with this reasoning, holding the view that making a process fatter to make it leaner is nonsensical: Such framing causes managers to get confused and lose focus.

Rather than force-fitting every operations strategy under the designation of Lean, the JOM has called for an exploration of alternatives to Lean, taking into consideration Lean practices and Lean's origin at Toyota.

Defining "Lean"

According to Wally Hopp and Mark Spearman in their article, "The Lenses of Lean: Visioning the Science and Practice of Efficiency" (Hopp & Spearman 2021), Lean has been practiced for centuries. Humans have been trying to make efficient use of resources since building the pyramids around 2,500 BC, through the first millennium in China, and into the scientific revolution in the 1600s.

Today's more modern definitions of Lean were born in the 20th century, starting with Henry Ford's flow-based ideas, losing touch with the emphasis on flow under mass production, and undergoing a radical rethinking by Toyota in the 1960s with the Toyota Production System (TPS). Hopp and Spearman observed the wide variety of ways Lean can be defined:

1. Lean is the pursuit of waste elimination
2. Lean seeks to minimize the cost of excess inventory, capacity or time
3. Lean is a systematic process for reducing the cost of waste
4. Lean is an organizational culture that encourages continual reduction of the cost of waste

Organizations in Unstable Environments may Benefit From Becoming Less Lean

In their editorial "A Lean View of Lean," authors Tyson R. Browning and de Treville make the point that the TPS, which was the starting point for Lean, "was developed for—and works best in—stable, predictable, repetitive contexts across a wide variety of industries." (Browning & de Treville, 2021)

What then, is the role of Lean for an operation that faces an unstable and unpredictable environment?

Just over 10 years ago—following the recession of 2008-2009 that generated challenges for effective supply-chain management—researcher Morgan Swink (2019) explored the ability of over 1,800 publicly held firms to survive before, during, and after the recession in a white paper published by the Association of Supply Chain Management (ASCM).

Swink found that resilient companies—defined by their ability to survive—had three main elements in common:

1. **They had a variable cost structure.** Companies that depended more on labor versus assets were more easily able to reduce labor and thus reduce variable costs.
2. **They had early warning systems in place.** Success was related to investment in monitoring and assessment capabilities allowing companies to better respond to change.
3. **They were described as lean.**

And, they survived for the most part by cutting any fat—that is, by becoming leaner. Key actions Swink mentions as helping these companies survive include:

- Cutting operation expenses
- Reducing working capital
- Rationalizing inventory
- Eliminating excess property and equipment
- Streamlining processes
- Focusing on cross-functional agility efforts (e.g., looking outside of supply chain solutions)

The results from Swink's study allow us to tease out the difference between (1) barely surviving, perhaps in an emaciated state and (2) emerging from crises stronger, fitter, more competitive, and more sustainable. Understanding this difference requires that we disambiguate buffer reduction and low cost.

Buffering Optimally Rather than Becoming Leaner

Hopp and Spearman (1996) elegantly captured the relationship between variability and buffering with a law in their book Factory Physics:

Variability-Buffering Law: Variability in a production system will be buffered by some combination of inventory, capacity and time. (Hopp & Spearman 1996, emphasis ours)

They provided an example of a sandwich shop. As you can imagine, demand varies throughout the day – lunchtime is much busier than later afternoon. Some sandwiches take longer to make than others, and ingredients may run out and need to be restocked. Dealing with this variability requires different solutions, many of which create buffers:

- A time buffer occurs when demand outpaces supply and people are waiting for their sandwiches.
- To deal with long customer wait times, managers might put more employees on sandwich-making duty, creating a capacity buffer.
- Another way to reduce the time buffer is to build an inventory buffer, which in this case means making extra sandwiches in advance. The strategy here would be to make sandwiches that are both commonly ordered and stay fresh the longest, otherwise they will need to be discarded.

Before the variability or disruption occurs, managers have the choice to buffer with capacity or inventory—or not to buffer, hoping that no variability or disruption will occur. If there is no buffer or the inventory buffer does not contain the right product, then the system will buffer with time. This time buffer will be unpleasant to the customer and is typically difficult to manage in a way that preserves a good relationship with the customer. Does this mean that the manager should throw capacity and inventory at the system to avoid time buffers and unhappy customers? The TPS provides a key insight: Time buffers can motivate process improvement.

Consider two adjacent workstations with a big pile of inventory between them. Suppose the upstream workstation is sometimes slow or adds defects to the part being produced. Because of the inventory buffer, the downstream workstation is not affected by the upstream performance problems, with defective units simply thrown to the side. Now suppose that we restrict the inventory between the two workstations. When the upstream workstation has a problem, the downstream workstation will not have a unit to process. The downstream worker then communicates to the upstream worker and the supervisor that there is a problem, and the problem may well get fixed. Also, the upstream worker becomes aware that their performance has implications for the entire line rather than just their workstation. In other words, reducing the inventory buffer created a time buffer that triggered process improvement. Buffer removals in the TPS were not intended primarily for cost reduction but rather to encourage process learning and improvement.

The TPS sets as a primary objective to eliminate variability and disruptions up front, which then reduces the need for buffers. These actions address variability in the form of quality problems, equipment downtime, and demand variability. To the degree that these actions eliminate variability, they also have the effect of reducing the need for buffers. This buffer reduction is dramatically different from the emaciation described by Swink, in which companies survived but were no longer positioned to thrive because they were too lean.

In “Commentary on the Lenses of Lean” in the JOM, Michael Cusumano also discusses the necessity of buffering to manage variability as he recalls the original designation of the TPS as “fragile” because of its reduced buffering (Cusumano et al. 2021). Gathering information from Taiichi Ohno, considered to be the father of TPS, and his observations of the Japanese auto industry in the 1980s, Cusumano analyzed the productivity advantages of the Toyota approach firsthand.

"The rapid feedback loops from small-lot production controlled through the pull system, combined with asking employees to inspect their own work before handing it off to the next station, led to faster learning, reduced defects, and fewer inspection staff—improving quality and productivity simultaneously...Toyota in the 1970s and 1980s was already producing more than twice as many vehicles per worker compared to GM, Ford, and Chrysler," he writes (Cusumano et al. 2021).

It is important to note the careful preparation for inventory reduction. In-process inventory often accumulates because of imbalances in the flow of production. A production problem downstream, for example, will result in inventory buildup upstream. This inventory does not serve to buffer the line from disruptions, but instead often has the effect of covering up problems, thus making them more difficult to resolve. The pull system prevented this useless inventory buildup—without reducing the amount of buffering in the system. When the system was stopped from building up inventory and instead focused on getting product smoothly through the line and to the customer, it resulted in dramatically more cars and sales without an increase in labor or equipment.

The exploratory use of inventory reduction between workstations to encourage learning exemplifies the trade-off between the resulting process improvements and the loss in throughput caused by the reduction in buffering. This trade-off is explored in detail by Suri and de Treville (1986).

Cusumano reinforces this point: "I...believe Ohno would have cautioned us to avoid extremes. For example, JIT production should improve efficiency and quality, but zero buffer inventories in a volatile environment can be disastrous if something goes wrong in the network and causes the production system to go down" (Cusumano et al. 2021).

Encouraging Managers to Consider Alternatives to Lean

Most managers take it for granted that the leaner the better for all operations in all contexts. Our message is that there are times when becoming less lean—fatter—leaves the organization better prepared for shocks of various types, whether coming from known or unknown unknowns. We would also like to draw attention to the fact that managers see extending supply chains toward low-cost producers as a Lean action, even though it results in dramatic increases in inventory buffering both to fill the supply chain and to provide safety stock for what appears to be a highly profitable product. Responsiveness and resilience require a clear distinction between low cost and low buffers.

In Japan in the 1990s, Sony and Canon faced a situation in which production in Japan was much more expensive than in neighboring countries, encouraging offshoring. R&D was located in Japan and the product was evolving rapidly. Demand was highly volatile, and leftover inventory retained little value. There were thus strong advantages to keeping production close by. A TPS consultant was brought in to advise how to implement TPS on these Japanese production lines. The TPS consultant took the view that TPS was not a good fit for this context because of the demand and product development shocks. He instead recommended a system called seru, the Japanese word for a biological cell. Rather than production lines producing a high volume of a standard product repetitively, seru called for the creation of cells for assembly, packaging, and testing to fulfill demand for orders. Cells were created for small, general-purpose machines on wheels that could quickly be organized into a cell. The transition to seru led to the dismantling of many large and highly automated machines: These machines were efficient at large volumes but not at the volumes required for volatile demand and rapid product evolution. Although the cells appeared to be more expensive in terms of production cost per unit, Sony and Canon were startled by the fact that they ended up making considerably more money. (The seru story is told in detail in Yin et al. 2017.)

Around the same time that word was spreading across the West about the achievements of the TPS, Goldratt proposed a competing path to improving the productivity of manufacturing that was based on identifying and correctly exploiting system bottlenecks according to his Theory of Constraints (ToC) (see Goldratt and Cox, 1984). Like the TPS, the ToC emphasized preventing unnecessary buildup caused by upstream production continuing when there was a downstream problem—or because of lack of demand for what was being produced. The ToC carefully evaluated the role of in-process buffers, recommending that bottlenecks be protected by modest buffers to ensure that they can operate at full capacity—but emphasizing strongly that building up inventory to keep a non-bottleneck fully deployed beyond the capacity of the bottleneck (or market) was pure waste. Like the TPS, the ToC drew attention to the importance of reducing the production lot size to avoid overproduction. A key difference with the ToC is that it was designed around job shops, whereas the TPS was designed around assembly lines with suppliers located close by. An effective ToC implementation would probably be considered to meet the criteria for Lean by most observers.

Suri's (1998) Quick Response Manufacturing (QRM) approach addresses the question of improving process performance from the viewpoint of lead time. A QRM implementation identifies bottlenecks and ensures that they have enough capacity to meet demand in a timely fashion, recalling that lead time increases exponentially as utilization approaches 100%. A second priority is to reduce production lot sizes because of the approximately linear increase in lead time that occurs with lot size.

All of these approaches are consistent with Hopp's and Spearman's (1996) Factory Physics and its rule that variability must be buffered. Buffering can take place through either inventory or capacity. As variability increases, either inventory will increase or capacity utilization will decrease. Ohno's ideas can be summarized in terms of their Factory Physics as: 1) reduce variability, 2) limit inventory buildup through pull production and lot-size reduction, and 3) explore whether capacity can be reduced.

What is our guidance for improving the performance (including resilience) of a manufacturing operation? A myopic focus on cost will hinder implementation of any of these approaches. The first step is to identify the demand and the bottleneck. An assembly line may have relatively balanced capacity between workstations, but there will still be one or two workstations that define the capacity of the line. The second step is to identify the inventory buildup that is not adding value and use one of the approaches to stop upstream production to avoid such buildup. Lot sizes should be reduced as much as possible, which may create new bottlenecks. Setup-time reduction at these workstations using TPS tools will increase the capacity of the entire line. All approaches call for the elimination of variability due to unplanned downtime, quality problems, or worker absenteeism. When the process is flowing smoothly enough that managers can get their brains around it, it is time to decide where buffers are needed—and to put in place a plan to perhaps eventually reduce that variability and buffering over time. But, in some cases, variability (like the demand variability faced by Sony and Canon) is to be expected and will require long-term buffering. In these cases, capacity buffering may well lead to higher performance and more responsiveness (even resilience) than inventory buffering.

What About Service Operations?

Although managers running service operations don't typically use standard TPS practices, in our experience they often refer to "running Lean" as highly desirable. Running Lean in a service operation seldom comes with drawing a process diagram, identifying bottlenecks, or thinking through the buffering needed to cover the variability inherent to serving customers. This way of thinking is particularly evident in startups that are struggling to reach profitability. The search for Lean often involves reducing headcount to a level that "should" meet "average" demand. A problem then emerges that could have been easily handled with sufficient capacity. With the reduced capacity, it instead explodes into a crisis that leaves the team exhausted and burned out: Key employees quit. A demand peak may well have a similar effect.

Whereas with manufacturing companies it is usually necessary to limit the buildup of in-process inventories, such inventory buildup is not common in-service operations. We recommend that these companies identify areas where adequate buffering will allow them to offer peaceful and excellent service to customers. When a manager from a service business announces that they are seeking to become Lean, we ask employees for examples that indicate excessive leanness—and usually get them. We suggest that Lean is unlikely to be the right focus for these companies, and that they instead focus on flow using one of the alternatives.

Definitions of Lean From the ASCM Supply Chain Dictionary

Lean enterprise:
A group of individuals, functions, and sometimes legally separate but operationally synchronized organizations. The value stream defines the lean enterprise. The objectives of the lean enterprise are to correctly specify value to the ultimate customer, and to analyze and focus the value stream so that it does everything from product development and production to sales and service in a way that actions that do not create value are removed and actions that do create value proceed in a continuous flow as pulled by the customer. Lean enterprise differs from a "virtual corporation" in which the organizational membership and structure keep changing.

Lean metric:
A metric that permits a balanced evaluation and response—quality without sacrificing quantity objectives. The types of metrics are financial, behavioral, and core-process performance.

Lean production:
A philosophy of production that emphasizes the minimization of the amount of all the resources (including time) used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management, and dealing with customers. Lean producers employ teams of multiskilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in potentially enormous variety. Lean production contains a set of principles and practices to reduce cost through the relentless removal of waste and through the simplification of all manufacturing and support processes.

ascm.org/learning-development/certifications-credentials/dictionary

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