Unveiling the Sustainability of Lean Production

.

ABSTRACT

For many decades, the lean concept has been praised for improving efficiency, maximizing productivity, and minimizing waste in manufacturing operations. Lean production is expected to create an industrial ecosystem that is more cost-efficient and accountable for optimizing resources and processes. However, in the context of lean manufacturing, new challenges have emerged as a result of the recent emphasis on sustainability. This study aims to show several criticisms of lean implementation and propose a holistic approach to achieve a more sustainable operation. The green-lean model, sustainable manufacturing, agile supply, and Lean 4.0, are approaches for integrating lean practices and sustainability. This will foster a culture of continuous improvement, employee empowerment, long-term collaboration with suppliers, added value for customers, and increased innovation in the economy.

Keywords: agile operation; green-lean model; lean concept; operation management; sustainable manufacturing

1. INTRODUCTION

A management philosophy known as the lean concept seeks to minimize waste and create the effectiveness of manufacturing operations. Lean production's underlying concepts have changed over time. Toyota invented this strategy in the 1950s, and Krafcik defined it in 1988 (Gil-Vilda et al.). The terms Japanese manufacturing methods, Just-In-Time (JIT) production, value-added process, continuous improvement operation, and stockless production were previously used and shared similar intentions to refer to the Toyota production system. Lean production/manufacturing, lean logistics, lean supply chain, lean thinking, and lean concept were some of the specifications used to define the phrase further.

Lean production has gained popularity over many years as a method to improve efficiency and reduce waste in manufacturing processes. Furthermore, the lean principles can be applied to service operations as well. Lean service was introduced in 1998 by Bowen in order to extend lean to industrial services (Ries). Many scholars believe that the lean process is a comprehensive solution to the challenges of traditional operations. While the lean concept has benefits, it is essential to examine its disadvantages and limitations critically.

2. THE LEAN PRODUCTION REVOLUTION

The constant pursuit of waste removal is at the core of lean production. In the context of lean manufacturing, waste includes not only physical waste but also any activity or resources that do not contribute value to the finished product. Lean procedures maximize effectiveness and resource use by locating and eliminating waste. Cost savings follow, making lean a financially sound practice (George et al.).

The Kaizen principle of continual improvement is a cornerstone of lean thinking (Womack and Jones). Employees at all levels actively participate in finding and implementing changes

owing to lean procedures. This iterative process ensures that the production system is constantly improved by adjusting to changing conditions and consumer needs. The capacity of lean production for adaptation makes it a dependable and progressive method of operation.

Another characteristic that distinguishes lean production is its focus on the JIT concepts. Companies using lean principles lower carrying costs and lessen the danger of obsolete stock by creating products in response to client demand rather than maintaining a large inventory. JIT encourages a more responsive and customer-centric approach to production in addition to producing considerable cost savings.

Flexible and adaptable staff members are highly valued in lean production systems. Employees' ability to execute several tasks ensures that the workforce is prepared to meet shifting production demands. As a result, efficiency is improved, and employees feel more empowered because they have a larger role in the organization's success as a whole (Kaban and Salim).

Lean production prioritizes quality control in efforts to reduce waste. The objective is to accomplish perfection—zero defects—rather than merely comply with industry standards. Lean approaches develop a culture of excellence by integrating quality into the production process from the outset, eliminating rework, and lowering the possibility of faults reaching the final consumer (Chopra).

Lean manufacturing is correlated with the rising importance of environmental sustainability (Casalegno), in addition to its economic benefits. Resource conservation naturally follows waste reduction, and lean firms frequently develop creative solutions to reduce their ecological imprints. Lean manufacturing helps create an industrial ecosystem that is greener and more responsible for streamlining processes and resources.

3. THE DOWNSIDE OF LEAN PRODUCTION

Lean production has received praise for its effectiveness and waste elimination; however, it is important to consider its drawbacks. There are disadvantages to any methodology, and lean production is no exception to this.

One of the main criticisms of lean production is its potential negative impact on employee well-being. The aim to reduce waste and boost efficiency may put too much pressure on employees to fulfill the challenging production goals which can lead to increased work intensity and stress (Berggren). As a result of being expected to work quickly and with little time for relaxation or breaks, employees may experience increased exhaustion and burnout. Such working conditions may be harmful to employees' mental and physical well-being, resulting in lower job satisfaction and higher turnover rates.

Lean manufacturing also frequently uses a flexible workforce, using temporary or part-time workers to fulfill changing production demands, which can lead to job losses (Berggren). While businesses may gain from this in terms of cost savings, it may also leave workers with unstable jobs. The use of temporary personnel may also result in a lack of training and expertise, which could lower the end product's quality. A trained and engaged workforce can be hampered by frequent employee turnover, which also has a detrimental effect on the company culture as a whole.

Lean production's susceptibility to supply chain bottlenecks is a serious risk as well (Cox and Chicksand). By depending on suppliers to precisely supply supplies and components when

required, the JIT strategy tries to reduce inventory. This limits the room for mistakes or unforeseen delays in supply networks, though. Any interruption, whether natural disasters, labor disputes, or transportation problems, can cause production to stop and cause big costs for businesses. During the COVID-19 pandemic, when global supply chains suffered serious disruptions and many businesses were unable to satisfy customer expectations, this vulnerability was made clear.

Lean production also places a strong emphasis on cutting costs and focusing on short-term efficiency gains at the expense of long-term investments in research and development, leading to the sacrifice of product quality (Williams et al.). The integrity and safety of the finished product run the risk of being compromised when prices are reduced, and procedures are simplified. A relentless focus on efficiency might result in poor quality control procedures and shortcuts that could compromise consumer safety. This has been displayed in a number of industries, such as the manufacturing of food and automobiles, where poor quality control has led to product recalls and safety issues. Thus, it should be noted that lean production may not be suitable for all industries or production processes and that it requires significant organizational and cultural changes to implement successfully (Berggren; Cox and Chicksand).

Lean manufacturing is believed to emphasize eliminating waste and improving productivity in the manufacturing process. However, it frequently ignores how manufacturing has an influence on the environment (Mor et al.). Increased energy use and carbon emissions may be the result of a focus on cutting inventory and minimizing waste. Additionally, the need to achieve strict production deadlines may result in the overuse of resources, which would worsen the environment (Cox and Chicksand). These harmful externalities are often ignored in favor of immediate cost savings.

4. TOWARDS A MORE HOLISTIC APPROACH

Although lean has demonstrated success in lowering costs and boosting productivity, it is becoming increasingly clear that a more comprehensive strategy is required to fully achieve its promise. Traditionally, lean has gained popularity as a management strategy in the area of operations, and it is suited for accomplishing these competitiveness goals through more efficient processes, shorter lead times, and increased flexibility in offering a wide range of goods and services (Liker). However, the lean methodology works best when there is a high volume, and predictable demand with supply assurance, allowing for the creation of useful products. Also, it typically overlooks other vital production elements that are ultimately critical to success, like employee satisfaction, environmental sustainability, and long-term strategic planning (Cox and Chicksand).

One of the key challenges of traditional lean production is its narrow focus on cost reduction and its short-term results. Organizations often neglect the long-term implications of their actions. Unintended consequences of this could include greater personnel turnover, lowered product quality, and harmful impacts on the environment (Jeston).

To address these limitations, a more holistic approach to lean production is required. This approach should consider the broader context in which production takes place and the interconnectedness of various factors (Gil-Vilda et al.). Employee happiness and engagement, for instance, should be a top priority because they are more likely to be productive and support ongoing improvement (Broccardo). A supportive work atmosphere, chances for training and growth, and employee participation in decision-making are all ways that organizations might accomplish this.

Environmental sustainability is another critical aspect that needs to be integrated into lean production practices (Casalegno). Although lean techniques aim to reduce waste, they often neglect the consumption of natural resources and their negative impact on the environment. A holistic approach would involve considering the entire product life cycle, from raw material extraction to disposal, and identifying opportunities to minimize environmental harm. It is encouraged that manufacturers combine the green model with lean concepts as suggested by Mor et al., (2015). Lean principles along with green models can improve efficiency and employee morale in various ways. The benefits of the lean concept, together with green models at the same time, help reduce environmental and human health risks throughout the product life cycle. Additionally, the integration of lean-green manufacturing practices can create environmentally friendly products. By adopting sustainable practices, manufacturing enterprises can improve their environmental performance, reduce costs, create a competitive advantage, and be more innovative across the value chain (Mor et al.).

Moreover, a sustainable production system can also be adopted by implementing the six elements as shown in Figure 1 below. Sustainable manufacturing is the creation of products using processes that minimize negative environmental impacts, and conserve energy and natural resources. In addition, it is more sustainable for workers, communities, and consumers, and is economically sound (Haapala et al.). Sustainable manufacturing includes not only creating products that address sustainability goals but also sustainable manufacturing systems for all products. This is important because it highlights the need for simultaneous consideration of economic, environmental, and social implications associated with producing and delivering goods.

Fig. 1. Sustainable Manufacturing Processes (Haapala et al.)

Adopting sustainable production practices could include the use of renewable materials, the implementation of energy-efficient processes, and recycling or reusing products and materials (Kirchmer). Therefore, companies can minimize their negative environmental footprint, conserve resources, ensure the safety and well-being of their employees and communities, and contribute to economic growth.

Furthermore, a more sustainable approach to lean production should not be confined to the factory floor. It should extend to the entire value chain; from suppliers to customers (Heizer et al.). By collaborating closely with suppliers and customers, organizations can identify areas for improvement and implement lean practices throughout the entire supply chain

(Fritz). This can lead to better coordination, reduced lead-times, and improved customer satisfaction. Cox proposed a more responsive and agile supply chain to be implemented for low-volume production (Cox and Chicksand). Table 1 below provides a comparison between Lean Supply and Agile Supply, which shows that implementing an agile supply is more suitable to be adapted in the always-changing market environment.

Table 1. Lean and Agile Product Profiles (Cox and Chicksand)

Distinguishing Attributes	Lean Supply	Agile Supply
Typical products	Functional products	Innovative products
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stockout penalties	Long-term contractual	Immediate and volatile
Purchasing policy	Buy materials	Assign capacity
Informatioin enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

Gil-Vilda proposed the evolution of lean management towards the current industry called Lean 4.0 (Gil-Vilda et al.). To overcome the limitations of traditional lean production, Lean 4.0 combines the latest technologies with lean operation principles and tools to achieve the optimum benefits. In contrast to traditional lean management, Lean 4.0 uses updated technology, including artificial intelligence, to assist with human decision-making in production control, continuous processes, and early prediction of machine failure. Artificial intelligence can be used to optimize production control by predicting the best sequence of operations, to maintain continuous pull flow by predicting the demand and adjusting the production accordingly, and to predict machine failure by analyzing the data from sensors and other sources. Eliminating waste and difficulty, obtaining a higher degree of operational excellence, and finding areas where lean tools and 4.0 technologies may work together are all advantages of Lean 4.0.

5. CONCLUSION

Although lean production has been successful in improving output and reducing waste, a more comprehensive approach is still needed to live up to its full potential. This approach should consider a broader context, including employee well-being, environmental sustainability, and the entire value chain in the production system. Linking lean practices with sustainability creates a streamlined production process responsive to customer demands, which signifies a holistic approach aimed at revolutionizing how value is created and waste is minimized. By adopting a comprehensive strategy, organizations can achieve long-term success, enhance business value, and create a more sustainable future.

ACKNOWLEDGMENTS

The author would like to acknowledge the study program of Doctor Research in Management, Universitas Pelita Harapan, and sincerely gratitude to Prof. Dr. Diena Mutiara Lemy, for the valuable insights and encouragement provided during the class on Sustainability and Social Value Creation.

REFERENCES

Berggren, Christian. 'Lean Production - the End of History?' *Work Employment & Society*, vol. 7, no. 2, 1993, pp. 163–88, https://doi.org/10.1177/095001709372001.

Broccardo, L. 'Sustainability as a Driver for Value Creation: A Business Model Analysis of Small and Medium Entreprises in the Italian Wine Sector'. *Journal of Cleaner Production*, vol. 259, 2020, https://doi.org/10.1016/j.jclepro.2020.120852.

Casalegno, C. 'Innovation Policy and Environmental Sustainability as Strategic Tools for Reaching Higher Performances. A Regional Empirical Analysis to Find the Best Practice'. *International Journal of Sustainable Society*, vol. 6, no. 1, 2014, pp. 170–88, https://doi.org/10.1504/IJSSOC.2014.057896.

Chopra, Sunil. *Supply Chain Management: Strategy, Planning, and Operation*. Pearson, 2021.

Cox, Andrew, and Dan Chicksand. 'The Limits of Lean Management Thinking'. *European Management Journal*, vol. 23, no. 6, Dec. 2005, pp. 648–62, https://doi.org/10.1016/j.emj.2005.10.010.

Fritz, M. M. 'Sustainability Management in Supply Chains: The Role of Familiness'. *Technological Forecasting and Social Change*, vol. 173, 2021, https://doi.org/10.1016/j.techfore.2021.121078.

George, Michael L., et al. *The Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools for Improving Process Quality, Speed, and Complexity*. McGraw-Hill, 2005.

Gil-Vilda, Francisco, et al. 'From Lean Production to Lean 4.0: A Systematic Literature Review with a Historical Perspective'. *Applied Sciences (Switzerland)*, vol. 11, no. 21, Nov. 2021, https://doi.org/10.3390/app112110318.

Haapala, Karl R., et al. 'A Review of Engineering Research in Sustainable Manufacturing'. *Proceedings of the ASME 2011 International Manufacturing Science and Engineering Conference*, 2011, https://www.researchgate.net/publication/263543140.

Heizer, Jay, et al. *Operations Management: Sustainability and Supply Chain Management*. Pearson, 2020.

Jeston, John. *Business Process Management: Practical Guidelines to Successful Implementations*. Routledge, 2022.

Kaban, Lila Maria, and Jasmine Salim. 'The Effect of Supply Chain Management and Competitive Advantage on Company Performance at PT Ahlindo Perkasa Alam'. *Universitas Putera Batam*, vol. 9, no. 2, 2021, pp. 116–22.

Kirchmer, Mathias. *High Performance Through Business Process Management: Strategy Execution in a Digital World*. Springer, 2017.

Liker, Jeffrey K. *The Toyota Way: 14 Management Principles From The World's Greatest Manufacturer*. McGraw Hill, 2008.

Mor, Rahul S., et al. 'Learning on Lean Production: A Review of Opinion and Research within Environmental Constraints'. *Operations and Supply Chain Management: An International Journal*, Sept. 2015, pp. 61–72, https://doi.org/10.31387/oscm0230161.

Ries, Eric. *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. Crown Publishing Group, 2011.

Williams, Karel, et al. 'Against Lean Production'. *Economy and Society*, vol. 21, no. 3, Aug. 1992, pp. 321–54, https://doi.org/10.1080/03085149200000016.

Womack, James P., and Daniel T. Jones. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Simon & Schuster, Inc., 2003.