BUILDING A RESILIENT SUPPLY CHAIN IN THE FACE OF GLOBAL UNCERTAINTIES BASED ON LEAN PRINCIPLES

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Abstract

In the 1980s and 1990s, globalisation established international supply chains to maximise production and economic efficiency. However, recent years have fundamentally changed how global trade and supply chains operate. Large-scale global events, geopolitical trade tensions, technological advances, changing demographics, rising interest rates, and inflation have all contributed to this shift. Consequently, companies must rethink and transform their supply chains to remain competitive in light of these developments. This paper seeks to identify the critical factors and drivers of supply chain disruptions and link them to Lean principles, known for their adaptability, to create a new and resilient supply chain. The paper presents relevant theories and concepts through a theoretical framework by analysing previous research on Lean principles in supply chain management. Building a new and resilient supply chain based on Lean principles has the potential to significantly adapt and enhance existing supply chains, thereby enabling companies to strengthen their competitiveness.

Key words: lean, supply chain, disruption, global uncertainties.

1. INTRODUCTION

In the 1980s and 1990s, globalisation established international supply chains to maximise production and economic efficiency. Technological advances that facilitated international trade and finance developed an extension of market forces beyond national borders, impacting economic activities at various levels. Global markets promote efficiency through competition and specialisation, allowing economies to focus on their strengths. They also provide access to more extensive, diverse markets and outstanding capital and technology (Staff et al., 2008).

However, recent years have fundamentally changed how global trade and supply chains operate. Large-scale global events, geopolitical trade tensions, technological advances, changing interest rates, and inflation have all contributed to this shift. Consequently, companies must rethink and transform their supply chains to remain competitive in light of these developments.

Experts believe that traditional supply chains may no longer be adequate in today's and tomorrow's world, and many companies are rethinking their global supply chain setup. In addition, firms must act quickly and decisively to have resilient supply chains and remain competitive (Knizek et al., 2022; Lynch et al., 2023).

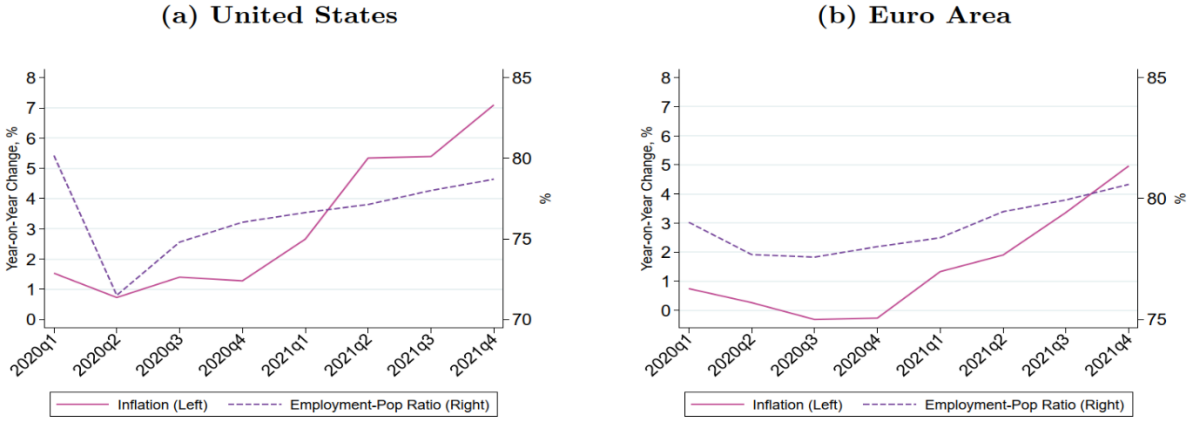
2. DISRUPTION ACROSS SUPPLY CHAINS

The COVID-19 pandemic has significantly impacted various supply chains around the globe. It has affected multiple dimensions of supply chains (SCs), including finance, lead times, demand changes, and production performance (Moosavi et al., 2022). Many companies have experienced disruptions due to logistics-related delays, shortages of production inputs, and increases in input prices (Knizek et al., 2022).

During the early phase of the pandemic outbreak around the world, there was a considerable negative supply shock, which disrupted supply chains and led to a substantial collapse in GDP due to uncertain demand. The pandemic impacted supply and demand, with supply shortages linked to production halts and labour shortages (Bhattacharjee et al., 2021; Shi et al., 2023).

In contrast, the recovery phase saw pent-up demand increase pressure on supply chains, resulting in inflation. This period can be characterised by a combination of negative supply and demand shocks in lockdown-sensitive sectors, alongside a positive demand shock in sectors like online deliveries. Despite a recovery in employment and real GDP, employment levels remain significantly below their pre-pandemic levels from late 2020 (Figure 1), when inflation began to rise in the US and Europe (Di Giovanni et al., 2022).

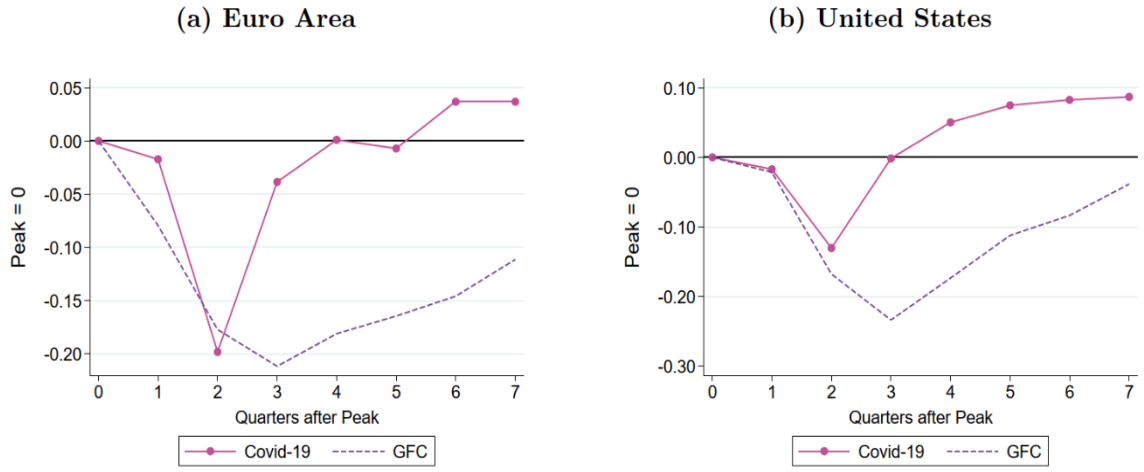
Figure 1. Inflation and Unemployment in the United States and Euro Area



Source: Di Giovanni et al. (2022), p. 4

Although government stimulus spurred aggregate demand, adverse sectoral supply shocks persisted globally. Shifts in demand between services and goods sectors are crucial for understanding inflation and international trade**.** While trade flows rebounded quickly, the shift towards goods exacerbated supply constraints, causing prices to rise despite increasing economic activity. During the early phase of the pandemic, world trade faced a significant disruption. Figure 2 shows the decline in world real imports and exports alongside the drop during the Global Financial Crisis (GFC) 2008, known as the Great Trade Collapse (GTC). While the initial decline worsened during the GTC, trade rebounded much more quickly during COVID-19 (Di Giovanni et al., 2022).

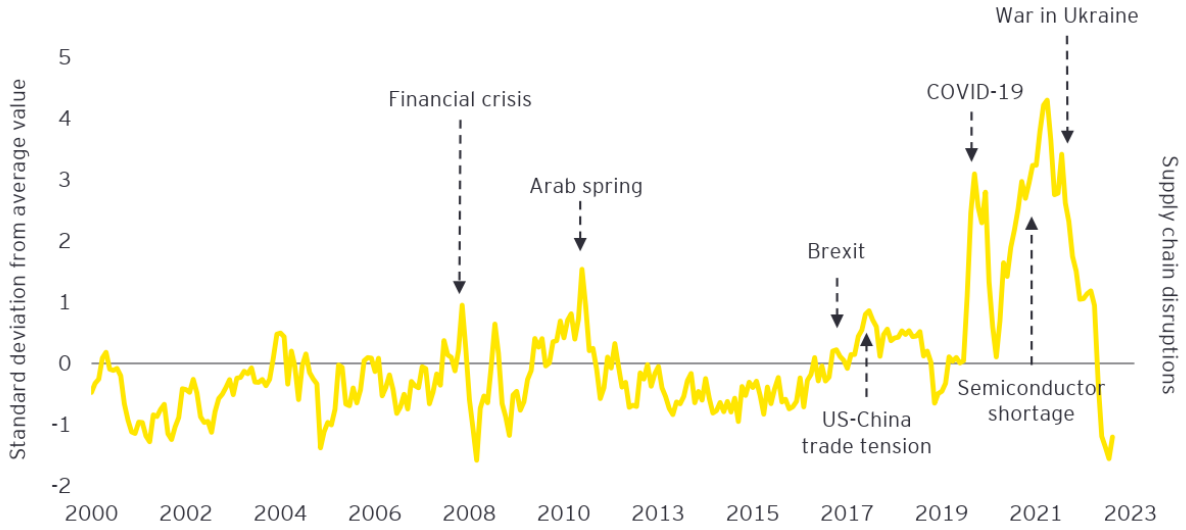
Figure 2. Import Quantity in Selected Countries during the GFC and Covid-19.



Source: Di Giovanni et al. (2022), p. 10

The war in Ukraine has resulted in immense human suffering and has also significantly affected global supply chains (Figure 3). Key impacts include rising energy and raw material costs, the destruction of regional industries, increased concerns over cyberattacks, and heightened operational complexity as companies adjust to new sanctions and greater scrutiny of their business relationships. Additionally, the range of policy measures directed at Russia and the potential for secondary sanctions against countries that maintain more conventional relations (such as China and India) may encourage nations to shield themselves and their domestic industries by selectively decoupling from existing supply chains. Foreign companies with operations or suppliers in these regions should engage in contingency planning to prepare for the sudden and possibly prolonged loss of these assets or relationships. (Knizek et al., 2022).

Figure 3. Global supply chain pressure index (GSCPI)



Source: Lynch et al. (2023), p. 3

3. LEAN PRINCIPLES IN SUPPLY CHAIN MANAGEMENT

Lean production and the term Lean itself originate from the Toyota production system developed in the 1990s. The earliest Lean principles date back to the early 1900s when Henry Ford introduced the assembly line principle that revolutionised automobile manufacturing. A significant advance in production philosophy occurred in Japan in 1949 when Toyota was forced to revise the existing production concept due to falling sales (Womack et al., 1990). Eiji Toyoda and Taichi Ono developed the principles of Lean manufacturing management. They presented ways to turn waste into value and shift the entire production system from artisanal production to worker productivity and mass machine production (Howell, 1999). It led to the introduction of the Toyota Production System, which resulted in the establishment of Lean Manufacturing in the 1990s.

According to the book "The Machine That Changed the World" (Womack et al., 1990), John Krafcik, a researcher at the IMVP International Motor Vehicle Program of the Massachusetts Institute of Technology, coined the term Lean because it requires twice as much factory labour, production space, engineer time, and warehouse space. This results in much fewer defects and increased product output (Womack et al., 1990).

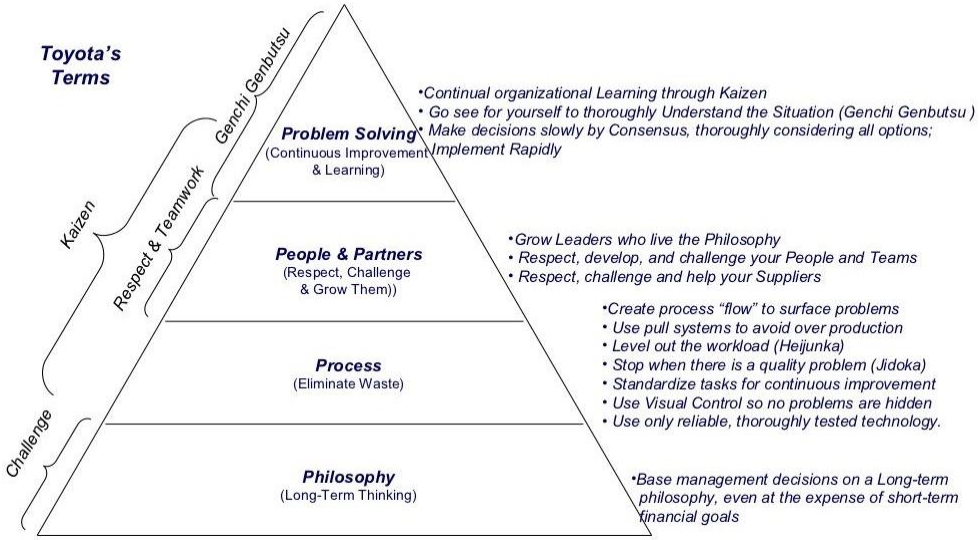
In order to better affirm the theoretical side and promote the Lean concept, Womack and Jones published a book called "Lean Thinking" in 1996 and defined five Lean principles in it (Womack and Jones, 1997):

- Accurately determine the value of a specific product - the value is viewed from the perspective of the end customer, who alone can define it.
- Identify the value stream for each product. The value stream includes all the actions required to deliver the product to the customer.

- Enable an uninterrupted flow of value - create a flow that creates value.
- Let the customer pull value from the producer - let the customer pull the product from the production system rather than the production system pushing it to the customer.
- Strive for perfection - there is no end to reducing process time, space, costs and errors.

In the same book, Womack (1997) defines Lean as "doing more with less" by using the least effort, energy, equipment, time, space, materials and capital - while giving customers exactly what they want. In addition, the Lean system can be viewed as a pyramid with different levels of implementation (Liker, 2004). The pyramid with the stages of implementation of Lean principles is presented in Figure 4.

Figure 4. Levels of implementation of Lean principles



Source of the figure: Liker (2004), p. 15

Waste should be understood as any inefficiency that results in the use of equipment, materials, labour or capital to a greater extent than necessary, as well as the occurrence of material losses and the performance of unnecessary work that creates additional costs and does not add value to the product (Boateng, 2019). Waste is usually understood in two dimensions (instrumental and intrinsic), with the primary goal to reduce or eliminate it to improve performance (Koskela et al., 2012). From the point of view of value creation, value is different for each end user, and it is the value that defines waste. Only value creation is the best way to reduce waste in design and construction (Mossman, 2009).

The creator of the Toyota Production System, Taichi Ono, devised seven wastes as part of this system (Ohno, 1988):

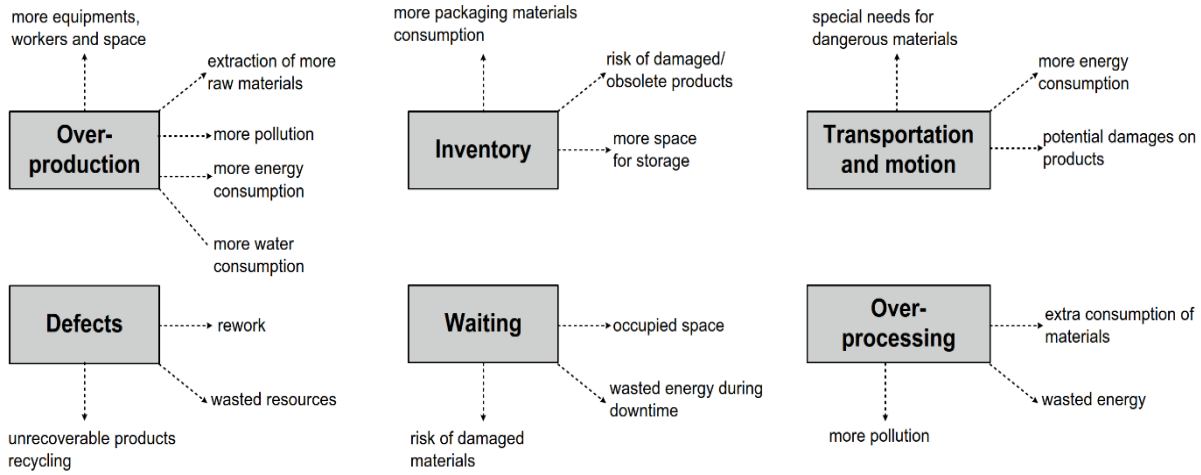
- Overproduction - leads to larger quantities of products than the needs of the market or customer. It is the production of items for which there are no orders, which leads to waste, such as excess labour, and higher storage and transportation costs due to

excess inventory (Liker, 2004). Overproduction is evident in the push system whose business strategy imposes products on the customer.

- Waiting-the waiting time between stages in production results in an inefficient workforce.
- Unnecessary transport - transporting products from one location to another increases energy costs. Poor organisation can lead to excessive transportation of materials or equipment (Forbes and Ahmed, 2010). Materials stored at a great distance from the installation site and inadequate delivery of materials to the organisation site can lead to multiple transportation of the same material.
- Overprocessing - Processing using inefficient methods requires more time and materials than necessary. This waste can also be defined as adding more value than the customer would be willing to pay (Boateng, 2019). Sometimes, designers create a much more complex and detailed project than required and thus make the execution of the works more complicated. On the other hand, performing work with inappropriate technology will also lead to inefficient use of time and materials.
- Excess inventory - Unnecessary inventory leads to excessive inventory-keeping costs. The cost of materials is significant, and a large amount of purchased materials can negatively affect cash flow. Keeping excess inventory involves storage costs.
- Unnecessary movement - additional movement represents unproductive work. Poor work organisation and workforce inexperience can create unnecessary additional steps to perform the work.
- Defects - Defective production requires repairs before delivery to the customer. Repairing, reworking, scrapping, replacing production, and conducting inspections lead to unnecessary handling, wasted time, and effort.

The eighth type of wastage represents unused employee creativity.

Figure 5. Effects of the production wastes



Source: Alves et al. (2019), p. 19

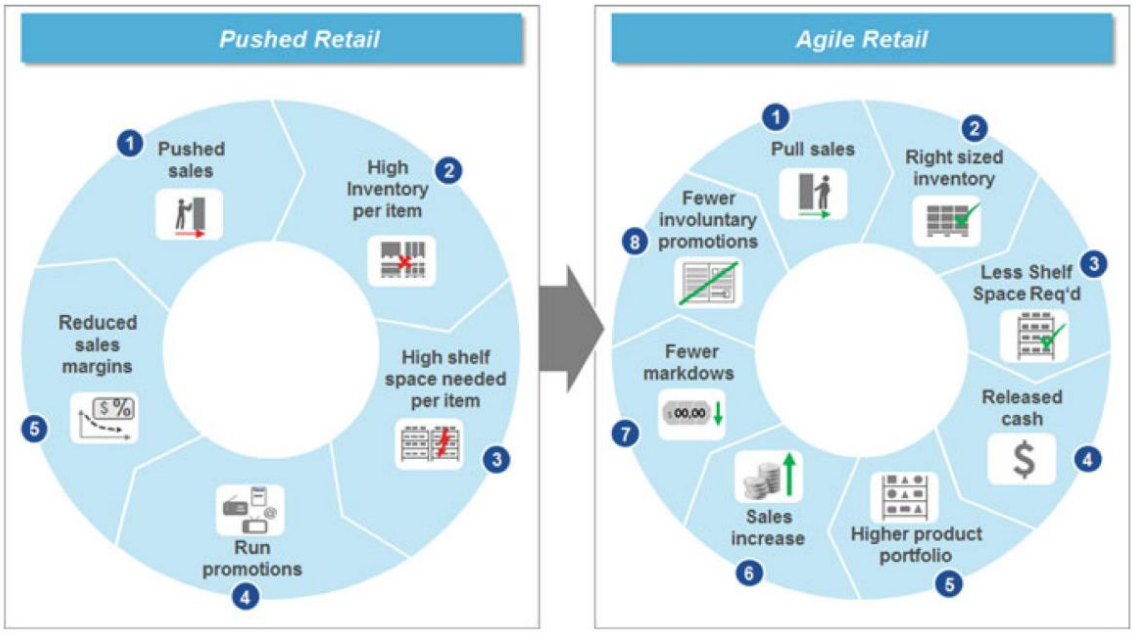
4. BUILDING A RESILIENT SUPPLY CHAIN BASED ON LEAN PRINCIPLES

To stay competitive, industrial leaders must focus on five key priorities to transform their supply chains and prepare for the future fundamentally:

Rapidly Redefine Supply Chain Strategy: Carefully assess global product flows, tax models, and network footprints. Implement a supply chain architecture that can effectively address new risks and opportunities (Knizek et al., 2022; Bednarski et al., 2024).

Design and Build Agility into the Supply Chain: Enhance responsiveness through real-time monitoring and scenario planning (Figure 5). Shift the team's and partners' mindset from a command-and-control approach to one focused on visibility and trust (Knizek et al., 2022) and flexibility and performance (Ivanov et al, 2019).

Figure 6. Transition from push to agile Supply Chain



Source: Ivanov et al. (2019), p. 90

Optimise Working Capital: Use supply chain reinvention as an opportunity to significantly improve the working capital profile by leveraging analytics and automation (Knizek et al., 2022).

Embrace Sustainability: Apply circular economy principles to engage suppliers and partners while driving competitive advantage and positive environmental outcomes. Connect corporate responsibility to the organisation and purpose (Knizek et al., 2022; Moosavi et al., 2022; Shi et al., 2023).

Shift from Doing Digital to Being Digital: Implement supply chain technologies that create new revenue streams rather than focusing solely on efficiency. Address the talent gap in digital fluency and navigate the challenges of emerging digital taxes (Knizek et al., 2022; Bednarski et al., 2024).

Many studies have indicated that during times of disruption, companies often shift away from the just-in-time method, commonly known as the Lean method (Knizek et al., 2022; Lynch et al., 2023; Bednarski et al., 2024). However, building a supply chain based on Lean principles can reinforce the defined priorities of their transformation. Additionally, eliminating waste associated with Lean practices can enhance the future progress of supply chains. By comparing the key priorities of supply chain transformation with Lean principles (Table 1) and waste (Table 2), we can identify optimal supply chain characteristics that effectively address global uncertainties.

Table 1. Key priorities of supply chain transformation and Lean principles comparison.

		Key priorities of supply chain transformation				
		Redefine Supply Chain	Agility	Working Capital optimisation	Sustainability	Digitalisation
Lean principles	Value determination					
	Value stream identification					
	Flow					
	Customer pull value					
	Perfection					

Value determination, identification of value, and facilitating an uninterrupted flow of value through a pull system are crucial in rapidly redefining the supply chain. Achieving supply chain agility hinges on recognizing value streams and extracting value from customers. Additionally, optimizing working capital and enhancing sustainability can be aided by value determination and maintaining a seamless flow of operations. However, striving for perfection can hinder the swift and agile transformation of the supply chain. While all Lean principles integrate with digitalization, they are not the sole determinants of success in this area.

Table 2. Key priorities of supply chain transformation and Lean principles comparison.

		Key priorities of supply chain transformation				
		Redefine Supply Chain	Agility	Working Capital optimisation	Sustainability	Digitalisation
Lean wastes	Overproduction					
	Waiting					
	Unnecessary transport					
	Over-processing					
	Excess inventory					
	Unnecessary movement					
	Defects					
	Unused employee creativity					

Eliminating waste such as overproduction, waiting, unnecessary transportation, over-processing, and unnecessary movement can help companies redefine their supply chains. To build agility in the supply chain, it's essential to focus on minimizing overproduction, waiting times, over-processing, and excess inventory. This approach can optimize the working capital profile by reducing these inefficiencies. Additionally, sustainability can be achieved by addressing overproduction, excess inventory, and defects. The elimination of defects is closely linked to the process of digitalization.

5. CONCLUSION

In recent years, global trade and global supply chains operations have undergone significant transformation. A combination of large-scale global events, geopolitical trade tensions, technological advancements, shifting demographics, rising interest rates, and inflation has driven this change. Consequently, companies must reconsider and transform their supply chains to maintain competitiveness in this dynamic environment. Establishing a new, resilient supply chain grounded in Lean principles can greatly enhance existing operations, thereby strengthening competitive edges. Essential to this transformation are the determination of value, the identification of value streams, and the facilitation of a continuous flow of value through a pull system. Achieving Agility in the supply chain requires a keen awareness of value streams and the ability to extract value from customer interactions. Additionally, optimizing working capital and improving Sustainability can be supported through effective value determination and streamlined operations. However, the pursuit of perfection may impede the swift and agile transformation necessary for today’s supply chains. While Lean principles align well with

digitalisation efforts, they are not the sole determinants of success in this arena. Eliminating waste - including overproduction, excessive waiting, unnecessary transportation, over-processing, and unnecessary movement - can substantially assist companies in redefining their supply chains. To foster Agility, it is crucial to minimize overproduction, reduce waiting times, limit over-processing, and manage excess inventory. This strategy not only enhances the working capital profile by addressing these inefficiencies but also contributes to Sustainability by tackling issues related to overproduction, surplus inventory, and defects. Furthermore, the elimination of defects is closely linked to the process of digitalisation.

LITERATURE

1. Alves, A. C., Kahlen, F. J., Flumerfelt, S., and Siriban-Manalang, A. B. (2019). *Lean engineering for global development*. Cham: Springer International Publishing.
2. Bednarski, L., Roscoe, S., Blome, C., and Schleper, M. C. (2024). Geopolitical disruptions in global supply chains: a state-of-the-art literature review. *Production Planning & Control*, 1-27.
3. Bhattacharjee, D., Bustamante, F., Curley, A., Perez, F. (2021). *Navigating the labor mismatch in us logistics and supply chains*. McKinsey & Company, 10.
4. Boateng, A. (2019). Supply Chain Management in the Ghanaian Building Construction Industry: A Lean Construction Perspective. In *Creative Construction Conference 2019. Budapest University of Technology and Economics*, 433.
5. Chen, Z., Hammad, A. W., Alyami, M. (2024). Building construction supply chain resilience under supply and demand uncertainties. *Automation in Construction, 158*, 105190.
6. Di Giovanni, J., Kalemli-Özcan, Ş., Silva, A., Yildirim, M. A. (2022). Global supply chain pressures, international trade, and inflation (No. w30240). *National Bureau of Economic Research*.
7. Howell, G. A. (1999). What is lean construction-1999. In *Proceedings IGLC, 7*(1). Citeseer, 2.
8. Ivanov, D., Tsipoulanidis, A., Schönberger, J. (2019). *Global supply chain and operations management*. Springer International Publishing.
9. Knizek, C., Jenner, F., Dharmani, S. (2022). *Why global industrial supply chains are decoupling*, E&Y.
10. Koskela, L., Sacks, R., Rooke, J. (2012). A Brief History of the Concept of Waste in Production. In *20th Conference of the International Group for Lean Construction*. The International Group for Lean Construction, pp. 6.
11. Liker, J. K. (2004). T*oyota way: 14 management principles from the world's greatest manufacturer*. McGraw-Hill Education.
12. Lynch, B., Rickert McCaffrey, C., Hanak, J., Sagar, A. (2023). *Navigating the shifts in supply chains*, E&Y.
13. Moosavi, J., Fathollahi-Fard, A. M., Dulebenets, M. A. (2022). Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies. *International Journal of Disaster Risk Reduction, 75*, 102983.

14. Mossman, A. (2009). Creating value: a sufficient way to eliminate waste in lean design and lean production. *Lean Construction Journal*.
15. Ohno, T. (1988). *Toyota Production System: Beyond Large-Scale Production*. CRC Press.
16. Shi, X., Liu, W., Zhang, J. (2023). Present and future trends of supply chain management in the presence of COVID-19: a structured literature review. I*nternational Journal of Logistics Research and Applications*, *26*(7), 813-842.
17. Staff, I. M. F., Di Giovanni, J., Gottselig, G., Jaumotte, F., Ricci, L. A., Tokarick, S. (2008). Globalization: A brief overview. *International Monetary Fund*, *2*(08).
18. Womack, J. P., Jones, D. T. (1997). Lean thinking-banish waste and create wealth in your corporation. *Journal of the Operational Research Society*, *48*(11), pp. 1.
19. Womack, J. P., Jones, D. T., Roos, D. (1990). *The machine that changed the world*. Simon and Schuster.