



## MIT SCALE RESEARCH REPORT

The MIT Global Supply Chain and Logistics Excellence (SCALE) Network is an international alliance of leading-edge research and education centers, dedicated to the development and dissemination of global innovation in supply chain and logistics.

The Global SCALE Network allows faculty, researchers, students, and affiliated companies from all six centers around the world to pool their expertise and collaborate on projects that will create supply chain and logistics innovations with global applications.

This reprint is intended to communicate research results of innovative supply chain research completed by faculty, researchers, and students of the Global SCALE Network, thereby contributing to the greater public knowledge about supply chains.

**For more information, contact**  
MIT Global SCALE Network

**Postal Address:**  
Massachusetts Institute of Technology 77  
Massachusetts Avenue, Cambridge, MA 02139 (USA)

**Location:**  
Building E40, Room 267  
1 Amherst St.

**Access:**  
Tel: +1 617-253-5320  
Fax: +1 617-253-4560

Email: [scale@mit.edu](mailto:scale@mit.edu)  
Website: [scale.mit.edu](http://scale.mit.edu)

**Research Report: ZLC-2005-1**  
**SC2020: Toyota Production System & Supply Chain**  
**Macharia Brown**

**For Full Thesis Version Please Contact:**

**Marta Romero**

**ZLOG Director**

Zaragoza Logistics Center (ZLC) Edificio

Náyade 5, C/Bari 55 – PLAZA 50197

Zaragoza, SPAIN

Email: [mromero@zlc.edu.es](mailto:mromero@zlc.edu.es)

Telephone: +34 976 077 605

# **SC2020: Toyota Production System & Supply Chain**

by

Macharia Brown

Submitted to Zaragoza Logistics Center in Partial Fulfillment of the Requirements for the  
Degree of

MASTER OF ENGINEERING IN LOGISTICS AND SUPPLY CHAIN  
MANAGEMENT

in the

MIT-ZARAGOZA INTERNATIONAL LOGISTICS PROGRAM

at the

ZARAGOZA LOGISTICS CENTER,  
A RESEARCH INSTITUTE ASSOCIATED WITH THE UNIVERSITY OF ZARAGOZA

## Executive Summary

Over the past 50 years Toyota created and honed a production system that fostered its ascension in the automotive industry. Furthermore, the concepts that fuel Toyota's production system extend beyond its manufacturing walls to the entire supply chain, creating a value chain where every link is profitable with an unwavering focus on teamwork, communication, efficient use of resources, elimination of waste, and continuous improvement. This report is a part of MIT's Supply Chain 2020 (SC2020) research project focusing on Toyota's production system and supply chain. The findings of this study illustrate how Toyota is able to use its production system as a source of competitive advantage throughout its supply chain. Toyota's production system has propelled it to become the world's 4<sup>th</sup> largest car manufacturer, in sales, behind General Motors, Ford, and Daimler Chrysler.<sup>1</sup> Toyota has experienced enduring success thanks to its combination of world-leading manufacturing, rapid product development, and devotion to customer satisfaction. Consequently, car manufacturers have rushed to embrace and adopt the principles of Toyota's Production System. The Toyota production system, closely related to lean manufacturing, has become the paragon for manufacturing across industries. Similarly, Toyota's supply chain structure and relations with suppliers has become a source of competitive advantage.

---

<sup>1</sup> Hoovers, 12 Feb. 2005  
<<http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41889>>.

The Toyota production system is widely recognized for its groundbreaking techniques as it is considered to be the next stage in development of manufacturing after mass production. It is the combination of each component of Toyota's production system that makes it a success. Subsequently, I will explain the main components of Toyota's production system that include: the SMED program, Jidoka, gradual elimination of muda (Kaizen, 5why's, Poka-Yoke), cross-trained workers, just-in-time production, and Heijunka.

### **SMED Program**

In the 1950s Toyota's chief production engineer, Taiichi Ohno, developed the idea of simple die changing techniques and to change dies frequently (every two-three hours versus two-three months).<sup>2</sup> Ohno used rollers to move dies in and out of position along with simple adjustment mechanisms. By purchasing a few used American presses and continually experimenting from the 1940s onward, Toyota was able to perfect Ohno's technique of quick changes. Consequently, Ohno had reduced the time required to change dies from a day to an amazing three minutes, and eliminated the need for die change specialists. Ohno's die change technique is now known as the Single Minute Die Change (SMED) program. By implementing the SMED program, Toyota discovered that it cost less per part to make small batches of stampings than to run off enormous lots. This holds true for two reasons:

1. "Making small batches eliminated the carrying cost of the huge inventories of finished parts that the mass production system required.
2. Making only a few parts before assembling them into a car caused stamping mistakes to show up almost instantly."<sup>3</sup>

The SMED program made workers in the stamping shop more concerned about quality and eliminated the waste of a large number of defective parts. Hence, the SMED program offered tremendous cost reductions through reduced inventory, and improved quality.

### **Jidoka**

Jidoka direct translation in English is automation. Today, Jidoka is referred to as autnomation, which is automation with human intelligence.<sup>4</sup> Jidoka also refers to stopping a manual line or process when something goes wrong. Ohno viewed the production process used by mass producers in the West to be rampant with muda – a Japanese term for waste that encompasses all elements of production that only increase cost without adding value. For instance, excess people, inventory, and equipment are all types of muda that may exist in a factory. In order to prevent mistakes from multiplying, Ohno placed a cord above every work station in the production facility and encouraged workers to stop the entire assembly line immediately if they discovered a problem. Once

---

<sup>2</sup> Ibid., 52.

<sup>3</sup> Ibid., 52.

<sup>4</sup> Strategies: Jidoka and Automation, 15 Apr. 2005 <<http://www.strategosinc.com/jidoka.htm>>.

the assembly line was stopped the problem would be addressed. Ohno implemented this method with the intention of making workers more conscious of quality through Jidoka. Jidoka places responsibility down to the assembly workers to ensure that they are mindful of the quality of each part produced.

### **Gradual Elimination of Muda**

As mentioned earlier, muda is Japanese term for waste that encompasses all elements of production that only increase cost without adding value: excess people, inventory, and equipment. The Toyota Production system reduces muda through three more ways: Kaizen, Root-Cause analysis, and Poka-Yoke.

Kaizen is a Japanese term for incremental improvement process. Taiichi Ohno was inspired to create Kaizen by the company suggestion system at Ford. Here, Ohno paired teams of assembly workers with industrial engineers to facilitate suggestions on ways to improve manufacturing processes.<sup>5</sup> Through Kaizen key members of the production process collectively come up with ways to improve quality, efficiency, and the work environment. By indoctrinating employees into the improvement frame of mind, they are able to identify opportunities for improving their jobs.

Root Cause analysis, the 5Why's, was created by Taiichi Ohno to serve as a systematic approach for workers to trace error back to its ultimate cause.<sup>6</sup> Under this philosophy, workers at Toyota are taught to ask why five times (5W) when confronted with a problem. Ohno asserts that "by repeating why 5 times, using the answer to each to develop the next question, the nature of the problem as well as its solution becomes clear."<sup>7</sup> The solution is referred to as the how-to or 1H. Consequently, 5W = 1H. This analysis helps assembly workers to determine the relationship between different root causes of a problem. It can be learned quickly and doesn't require statistical analysis to be used.<sup>8</sup>

Shigeo Shingo, one of Toyota's chief engineers, is credited with the idea of Poka-Yoke. Poka-Yoke is regarded as mistake proofing production processes. This is a manufacturing technique of "preventing errors by designing the manufacturing process, equipment, and tools so that an operation literally cannot be performed incorrectly."<sup>9</sup> This approach is to prevent mistakes before they occur in order to reduce failure. A Poka-Yoke device is one that prevents incorrect parts from being made or assembled. An example of a Poka-Yoke device for the automotive industry is when you make sure an assembler uses three screws by packaging the screws in groups of three. Effective Poka-Yoke devices make before-the-fact inspection more effective by reducing the time and cost of inspection to near zero.<sup>10</sup>

### **Cross Trained Workers**

---

<sup>5</sup> Ibid., 149.

<sup>6</sup> Taiichi Ohno, *Toyota Production System* (Portland, Oregon: Productivity Press, 1978) 17.

<sup>7</sup> Ibid., 18.

<sup>8</sup> Doug William and Associates: *5whys*, 22 Mar. 2005 <<http://www.dwassoc.com/5-whys.php>>.

<sup>9</sup> *Prevent Mistakes with Poka-Yoke*, 12 Apr. 2005 <<http://www.school-for-champions.com/tqm/poka-yoke.htm>>.

<sup>10</sup> *Prevent Mistakes with Poka-Yoke*, 12 Apr. 2005 <<http://www.school-for-champions.com/tqm/poka-yoke.htm>>.

At Toyota, Ohno grouped assembly workers into teams with a team leader who performed assembly tasks in addition to coordinating the team.<sup>11</sup> This formally eliminated the position of foreman. Next, he gave the team the job of house-keeping, minor tool repair, and quality checking. By cross training his employees, Ohno eradicated the need for specialists, and lowered operational cost by reducing the workforce. Cross training workers removed muda by eliminating the excess people used in the mass production system, and countless idle time (changing dies, house-keeping) that existed in the Western production system. Moreover, Cross trained workers improve worker skill level, production efficiency, and lowers cost within the Toyota Production System.

### **Just-In-Time Production**

Just-In-Time is a way to coordinate the flow of parts within a supply system on a day to day basis. Inspired by practices at American supermarkets, Taiichi Ohno sought to incorporate a just-in-time process at Toyota. The motivation behind just-in-time is to reduce stock. Just-in-time causes a reduction in stock by decreasing overproduction, stock on hand, and work in process.<sup>12</sup> Overproduction occurs in traditional mass production systems because companies keep extra stock on hand to respond to the fluctuations in demand that regularly occur. In just-in-time environments, lot sizes are smaller and production is synchronized enabling manufacturers to easily change production schedules.<sup>13</sup> Toyota's just-in-time system affords it the opportunity to be more responsive to unpredictable demand. Work in process, work that is waiting in between processes, is reduced in the just-in-time environment because materials arrive at the process just as they are needed; therefore, inventory is eliminated.<sup>14</sup> Stock on hand, material that is actually being worked on is reduced in the just-in-time environment because smaller lots reduce the amount of stock needed at the machines to run. Reductions in stock give Toyota more flexibility with their production decisions and afford the company cost reductions throughout the entire supply chain.

### **Heijunka**

The production schedule at Toyota is determined by demand leveling and Heijunka – a Japanese term for make flat and level/smoothing the waves of production. First, “demand leveling breaks down the total volume of orders for a given planning period (1-2 months) into scheduling intervals (weekly, daily). A Heijunka calculation then defines a repetitive production sequence for the scheduling interval, which dictates

---

<sup>11</sup> Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 56.

<sup>12</sup> Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

<sup>13</sup> Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

<sup>14</sup> Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

the model mix scheduled on a given line.”<sup>15</sup> The schedule is then passed into operation through the production and distribution of Kanban cards. Through the use of demand leveling and Heijunka scheduling, Toyota is able to meet demand, which is often variable, without holding excess inventory. Consequently, fluctuations in demand are absorbed and production batch sizes, variety, and sequencing are managed.

### **Supply Chain**

Several components of Toyota’s production system extend beyond its manufacturing walls into every link of its supply chain. For instance, Toyota extends its practice of just-in-time manufacturing principles to its suppliers. Therefore, every member of the Toyota supply chain decreases overproduction, stock on hand, and work in process. As a result, cost is reduced throughout the entire supply chain. This practice is a contrast to automakers that merely focus on reducing their own stock by pressuring suppliers to hold excess inventory. Under such a system, cost of extra inventory is transferred to other links within the supply chain. At Toyota, production schedules (when to produce and how much to produce, when to order and how much to order) are pulled through the entire supply chain eliminating coordination issues. Toyota pressures suppliers to share information (vertically and horizontally) so that waste is reduced throughout the supply chain in order to lower cost. In doing so, suppliers are able to improve their manufacturing techniques by learning from each other. By adopting the principles established in its production system, Toyota is able to add value to every member of its supply chain. This has propelled Toyota to become the most profitable automaker in the automotive industry.

---

<sup>15</sup> FactoryLogic: Leading Lean, 1 Apr. 2005 <[http://www.factorylogic.com/nl\\_26.asp](http://www.factorylogic.com/nl_26.asp)>.