The Origins of Lean Manufacturing and Lessons for Today

Christoph Roser
Karlsruhe University of Applied Sciences, Germany

1 Introduction

There is a consensus in industry that lean manufacturing is one of the best, if not the best, approach to improving manufacturing and related operations. Properly implemented, this continuous improvement approach will reduce waste, unevenness, and overburden, while giving respect to all stakeholders.

It is common knowledge that lean production originated in the Toyota Production System. The largest influencer was arguably Taiichi Ohno (1912–1990), also known as the father of the Toyota Production System. During the period between 1950 and 1970, he developed most of what we nowadays know as lean production. This helped to make the Toyota Motor Company one of the largest, most profitable, and best companies in the world.

However, Toyota did not develop this system out of the blue; it was inspired by many other companies and events. In the following I would like to give an overview of the major influences that helped form the Toyota Production System and subsequently lean production. Below are different major influencers.

2 United States

Probably the biggest influence outside of Japan was America. Even before World War II but especially during and after, the United States was the industrial powerhouse and role model for development at Toyota. During multiple visits, engineers and managers from Toyota got many ideas from the United States.

2.1 Henry Ford

Within the United States, the Ford Motor Company had an enormous influence on Toyota. The modern **assembly line** originated with Ford. But Ford also had a relentless drive to avoid waste. Already before World War I, Ford did what would nowadays be called "**waste walks,**" trying to reduce material waste, recycle scrap parts, and reduce waiting times.

Figure 1: Ford Magneto assembly line, one of the first, if not the first, assembly line at Ford 1913 (public domain)

Another idea that originated at Ford was for the operators to stop the assembly line by pulling a cord if there was a problem. This prevented pushing problems downstream in the assembly line. While the idea originated at Ford, nowadays this is seen as a Japanese invention and called "**Andon**" or "**Andon line.**"

Yet another idea at Ford was the **employee suggestion system**. Workers were encouraged to provide ideas to improve the manufacturing system. Eiji Toyoda brought back a Ford employee suggestion booklet from his 1950 visit to Ford. Toyota copied that approach and excelled at it. While the system fell into disuse at Ford, Toyota now has one of the strongest employee suggestion systems in the world. Even decades later, Toyota used the original Ford manuals as a reference for their employee suggestion system.

2.2 Retail Supermarkets

We know **supermarkets** as the place we go to get our groceries. In manufacturing, supermarkets are also inventories of goods. The name originates from retail supermarkets that started in 1916 in the United States. Before then, goods were purchased at a "mom-and-pop store," where you told the clerk what you wanted and the clerk then got it for you. In a modern supermarket, however, you get the goods yourself.

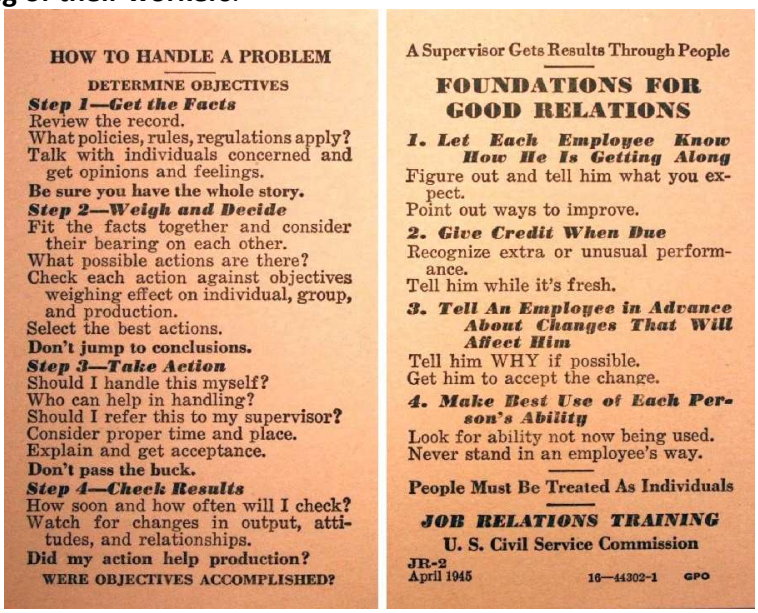
More significantly, a supermarket also organizes the reordering of goods. A supermarket counts how much goods of which type were sold and then simply reorders the same number of goods from their wholesale suppliers. This is also the novel feature of a manufacturing supermarket. Rather than having a manager or clerk decide what to produce, using a supermarket you simply reproduce or, more generally, reorder what was consumed from the supermarket.

Figure 2: The original Piggly-Wiggly supermarket in Memphis, 1916 (copyright expired)

A school friend of Taiichi Ohno visited the United States and brought back photos and reports. This helped Ohno develop the manufacturing supermarkets based on retail supermarkets. He saw his first real supermarket only much later in life.

2.3 Training within Industry

During World War II, most qualified American workers were fighting overseas. To keep the war industry up and running, the US government started a program to quickly and efficiently train new workers. This program was Training within Industry (TWI). With its components Job Instructions, Job Methods, and Job Relations, TWI was a very efficient and structured way to bring new workers up to speed, and the training time was reduced from years to merely months. This also influenced Toyota, and TWI manuals were studied and applied toward the **training of their workers**.



HOW TO HANDLE A PROBLEM

DETERMINE OBJECTIVES

Step 1—Get the Facts
Review the record.
What policies, rules, regulations apply?
Talk with individuals concerned and get opinions and feelings.
Be sure you have the whole story.

Step 2—Weigh and Decide
Fit the facts together and consider their bearing on each other.
What possible actions are there?
Check each action against objectives weighing effect on individual, group, and production.
Select the best actions.
Don't jump to conclusions.

Step 3—Take Action
Should I handle this myself?
Who can help in handling?
Should I refer this to my supervisor?
Consider proper time and place.
Explain and get acceptance.
Don't pass the buck.

Step 4—Check Results
How soon and how often will I check?
Watch for changes in output, attitudes, and relationships.
Did my action help production?

WERE OBJECTIVES ACCOMPLISHED?

A Supervisor Gets Results Through People

FOUNDATIONS FOR GOOD RELATIONS

1. Let Each Employee Know How He Is Getting Along
Figure out and tell him what you expect.
Point out ways to improve.

2. Give Credit When Due
Recognize extra or unusual performance.
Tell him while it's fresh.

3. Tell An Employee in Advance About Changes That Will Affect Him
Tell him WHY if possible.
Get him to accept the change.

4. Make Best Use of Each Person's Ability
Look for ability not now being used.
Never stand in an employee's way.

People Must Be Treated As Individuals

JOB RELATIONS TRAINING

U. S. Civil Service Commission

JR-2
April 1945 16—44302-1 GPO

Figure 3: A TWI Job Relations card with the key points for good relations (public domain)

2.4 Statistical Process Control

Toyota is well known for its quality. However, it has not always been that way. For example, when the first shipment of Toyota automobiles to America was damaged in a storm, salespeople were relieved that they did not have to sell these low-quality products. Toyota achieved its legendary quality only much later. The key influence for product quality was from the United States, especially **statistical quality control** (SPC).

SPC was developed by Walter A. Shewhart around 1920, and was extensively and successfully used during World War II to improve product quality. After the war, however, the US industry mostly reverted back to its old ways. Consultants specializing in SPC had difficulties in finding work. Some of them were invited by the US occupational forces to come to Japan and teach the Japanese SPC. While SPC was lacking in the United States, it fell on very fertile ground in Japan. Especially, W. Edwards Deming (1900–1993) is still revered in Japan as a quality guru, but Joseph M. Juran (1904–2008) was probably even more influential.

Toyota improved and refined these methods, further naming them Total Quality Control TQC. Through lean, this was re-introduced in America again as Total Quality Management (TQM), which enjoys a much higher popularity than the original SPC.

2.5 SMED from the Danly Corporation

One of the most well known – and possibly even overrated – methods in lean is **SMED**, standing for Single Minute Exchange of Die. Ford produced large quantities of cars and had a machine customized for every part. Toyota in the 1950s produced much less, and a machine had to produce parts for different products. The changeover was troublesome, especially for the large stamping presses. Since it took two to eight hours to change the tool (die), capacity and flexibility was severely hampered. Hence, Toyota started a Quick Die Change (QDC) effort to reduce changeover time.

For this, Toyota found inspiration in many sources. Here again, TWI surfaced. TWI had a program, ECRS (Eliminate, Combine, Rearrange, and Simplify), which is very similar to the modern SMED. Toyota also learned from the US Danly Machine and Clearing, which already implemented many time-saving features to the tool change of their presses. Toyota first saw these presses in the United States and subsequently also bought some Danly machines.

Again, Toyota improved these approaches. While initially it took them two to eight hours for a tool change in 1950, they needed only three minutes in 1970. During one of the last workshops, an external consultant, Shigeo Shingo (1909–1990), was involved. After he fell out with Toyota, he moved to the United States and rebranded the method as the now-familiar SMED.

3 Takt Time from Junkers Germany

In lean manufacturing, the average rate at which a customer wants product is a very important measure. This is called the **takt time**, after the German word *Takt* (pulse, stroke, gating, timing, beat). Junkers Aircraft plants organized their production so different steps were timed so that the airplanes moved to the next stations at fixed intervals. This method was called

Taktverfahren (Takt method). This was not a moving assembly line as with Henry Ford but a pulse line that moved at fixed intervals (the takt).

Figure 4: Junkers JU 87 assembly line hall. (Image by Bundesarchiv, Bild 101I-642-4711-08 / Seuffert and licensed under the Creative Commons Attribution-Share Alike 3.0 Germany license)

This system was also used during World War II in Germany. During that time, about 250 German aircraft engineers and technicians moved to Japan to support the wartime production of their Japanese ally. Through this contact, Mitsubishi learned about the Takt. From Mitsubishi, the method spread to Toyota, and hence lean production uses the German word Takt, albeit nowadays usually to describe the average customer demand rather than the line speed.

4 Japan

4.1 Japanese Craftsmanship and Continuous Improvement: Monotsukuri

Naturally, a lot of ideas and trends also emerged in Japan. Probably one of the reasons for the success of the Toyota Production System is the value and respect given to craftsmen in Japan. For example, while in the Western world we know artists like Shakespeare or Rembrandt, in Japan there are also almost-as-famous potters, swordsmiths, and carpenters who are known to a large part of the population. Or, to give you another example, instead of saying goodbye at the end of the work day, the Japanese say *gokurosama*, which means “thank you for the (physical) work.”

Overall, craftsmen take immense pride in their work and want to make the best product possible. This ideology is called *monotsukuri*, literally “making things by hand.” The quest to make the best possible product is surely one strong influence on the continuous-improvement approach **kaizen**.

4.2 Small Lot Sizes at Nichibo

Before working for Toyota, Ohno was working for the parent company, Toyoda Spinning & Weaving. Its main competitor in Japan was Nichibo, which somehow was able to produce better quality at a lower cost. Ohno was sent to learn their methods. Whereas Toyoda back then used large lot sizes with different buildings for different processes, Nichibo preferred to work with small lot sizes and integrated manufacturing lines. Hence, Nichibo may have been one of Ohno’s inspirations for a constant reduction in inventory and the goal of a lot size of one.

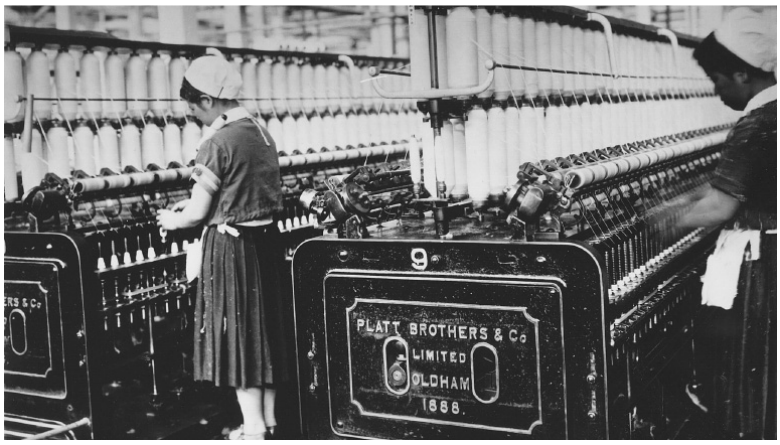


Figure 5: Hirano mills of Dai-Nippon Spinning Company (Nichibo), around 1900 (copyright expired)

4.3 Toyoda Automatic Loom: Poka Yoke and Jidouka

Before the Toyota Motor Company, there was Toyoda Spinning & Weaving, founded by Sakichi Toyoda (1867–1930), also known as the king of inventors. One major problem with looms was broken threads. A broken thread that was not detected early enough could ruin a lot of cloth. Toyoda invented, among other things, an automatic loom that stopped itself in case of broken threads.

In lean manufacturing parlance, these (semi-) intelligent machines or processes that stop by themselves if a problem occurs, are known as *jidouka*, usually translated with the invented word *Autonomation*. A related term would be idiot-proofing, or *baka-yoke*, although Shigeo Shingo renamed this for the Western world into the much less controversial mistake-proofing, or *poka-yoke*.

4.4 World War II Material Shortages

Yet another major influence was World War II, in particular the war-related material shortages. There was a constant shortage of raw materials needed to produce. Like many other countries during World War II, Japan's government took control of the distribution, which overall resulted in a very inefficient mess.

Due to lack of materials, Toyota was even forced to produce military trucks with only one headlight and only two brakes at the rear axle. Overall, this constant shortage of material surely influenced Ohno and others at Toyota. Luckily for us, they did not revert into gluttony afterward, but learned from these problems and managed to run a company with little material.

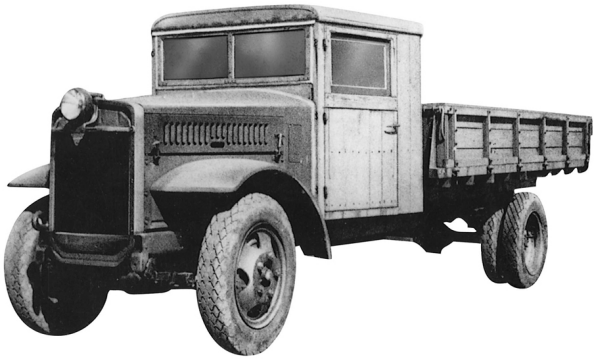


Figure 6: 1943–1947 Toyota Model K Truck with only one headlight (copyright expired in Japan)

5 Lessons for Today

Overall, there were many influences that helped develop the Toyota Production System and its Western variant, lean production. I often hear or read that "*We invented lean long before, and Toyota only copied it,*" usually with the underlying tone that this person's country is better than Japan.

It is true that Toyota copied a lot of ideas from others. But most companies do so. Toyota, however, combined these ideas into a coherent working production system that improved and excelled many of these ideas. The way Toyota combined and built on these influences is unique, and in my view truly the best production system in the world for a large company.

In fact, the true strength of Toyota is not its production system; that itself is only a side effect. The true strength of Toyota is its ability to continually learn and reinvent itself. As long as Toyota keeps this strength, the company will continue to prosper. Lean manufacturing in the Western world often fails because Westerners copy only the underlying methods and fail to understand the philosophy and attention to detail that is behind them. While many companies claim to be excellent, so far I have not yet seen any large company that even comes close to Toyota.

This is also the main lesson: Learn, understand, and adapt. Visit other plants, countries, and locations, and take inspirations from there for your own industry. As soon as you rest on your achievements, you will fall back. For a company to be successful in the long run, it has to change and adapt to the changing needs of the customer and the abilities of the competitor. Lifelong learning applies not only to individuals but also to organizations.

P.S.: Much of the above information is from my book *"Faster, Better, Cheaper" in the History of Manufacturing: From the Stone Age to Lean Manufacturing and Beyond*, Roser, Christoph, 439 pages, Productivity Press, 2016.