SC2020:
Toyota Production System
&
Supply Chain

by

Macharia Brown

Bachelor of Science in Comparative Politics
United States Military Academy, West Point 2003

Submitted to Zaragoza Logistics Center in Fulfillment of the Requirement for the Degree of

Master of Engineering in Logistics and Supply Chain Management
at the Zaragoza Logistics Center
June 2005

Signature of Author _____

Zaragoza Logistics Center
May 10th, 2005

Certified by _____

Prashant Yadav, PhD ZLC
Thesis Supervisor

Approved by _____

Larry Lapide, PhD.
Research Director, MIT-CTL

Toyota Production System
&
Supply Chain

by

Macharia Brown

Bachelor of Science in Comparitive Politics
United States Military Academy, West Point 2003

Submitted to Zaragoza Logistics Center in Fulfillment of the Requirement for the Degree of Master of Engineering in Logistics and Supply Chain Management

Abstract

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 study begins by examining the automotive industry, evolution of top 5 automotive companies, and Toyota's positioning against its main competitors. Finally, the report explores the main components of Toyota's production system and its supply chain structure. 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.

Toyota Production System
&
Supply Chain

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 4th largest car manufacturer, in sales, behind General Motors, Ford, and Daimler Chrysler.[1] 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.

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

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

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).[2] 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."[3]

[2] Ibid., 52.
[3] Ibid., 52.

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 autonomation, which is automation with human intelligence.[4] 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 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,

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

inventory, and equipment. The Toyota Production system reduces muda through Kaizen, Root-Cause analysis, and Poka-Yoke.

Kaizen is a Japanese term for incremental improvement process. Taiichi Ohno was inspired to implement Kaizen at Toyota 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.[5] 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, employees 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.[6] 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."[7] 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.[8]

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

[5] Ibid., 149.
[6] Taiichi Ohno, Toyota Production System (Portland, Oregon: Productivity Press, 1978) 17.
[7] Ibid., 18.
[8] Doug William and Associates: 5whys, 22 Mar. 2005 <http://www.dwassoc.com/5-whys.php>.

manufacturing technique of "preventing errors by designing the manufacturing process, equipment, and tools so that an operation literally cannot be performed incorrectly."[9] The approach is to prevent mistakes before they occur in order to reduce failure. A Poke-Yoke device is one that prevents incorrect parts from being made or assembled. An example of a Poke-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.[10]

Cross Trained Workers

At Toyota, Ohno grouped assembly workers into teams with a team leader who performed assembly tasks in addition to coordinating the team.[11] 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 lower cost within the Toyota Production System.

Just-In-Time Production

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

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

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

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.[12] 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.[13] 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 and therefore the inventory is eliminated. [14] 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.

[12] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.
[13] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.
[14] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

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 the model mix scheduled on a given line."[15] 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.

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 are (when to produce and how much to produce, when to order and how much to order) 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

[15] FactoryLogic: Leading Lean, 1 Apr. 2005 <http://www.factorylogic.com/nl_26.asp>.

member of its supply chain. This has propelled Toyota to become the most profitable automaker in the automotive industry.

ACKNOWLEDGEMENTS

I would first like to thank my parents, Pauline Clarke and the late Horace Michael Brown. Over the course of my life, both have inspired me in many ways. My mother's prayers, encouragement, love, and patience, was felt this entire year from across the Atlantic Ocean.

Secondly, I would like to thank my brother and sister, Jelani Brown and Bianca Dalrymple. Jelani, our relationship has allowed me to develop into the man that I am today. I would not have achieved half of what I was able to had I not had you in my life. Bianca, you have indirectly taught me many lessons in life. I admire you and all your accomplishments. Beautiful, continue to make me proud!

Third, I would like to thank the remaining members of my family (Grandparents, Aunts, Uncles, Cousins, and Friends). I hope this report serves as a 'Team' accomplishment.

Special thanks go to the following individuals: Joseph and Kris Pruett. Your friendship has taught me many invaluable lessons on life. Thank you for everything.

I would like to acknowledge the entire faculty and staff of the Zaragoza Logistics Center. Their continued support made the completion of this work a reality.

Also, I would like to personally extend my thanks to my advisor, Prashant Yadav, for his guidance throughout this entire process.

Finally, I would like to thank Larry Lapide, Research Director for MIT's Supply Chain 2020 (SC2020) project, for his leadership throughout the duration of the project. Larry is a consummate professional. His intellectual contributions, insight, and support were central to the development of this thesis and the entire SC2020 project.

Lastly, I would like to thank Dwayne Cameron and ---- for the personal support they provided me throughout my entire life. Whenever I needed inspiration, you guys were their. Thanks.

This thesis is dedicated to my brother Damien Oliver Dalrymple and the members of the USMA class of 2003 who are proudly serving our nation.

Table Of Contents

Table of Figures

Chapter 1. Introduction

The Supply Chain 2020 (SC2020) Project is a multiyear research effort to identify and analyze the factors that are critical to the success of future supply chains. This study is SC2020's focus on the automotive industry. 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 4th largest car manufacturer, in sales, behind General Motors, Ford, and Daimler Chrysler.[16] 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.

This study begins with an analysis of the automotive industry in chapter three. The analysis includes: products and services, historical revenues, operating margins, customer segments, sales channels, supply chain structure, and industry trends and drivers. Lastly, chapter three provides information on the evolution of the top five automotive companies. Chapter four examines Toyota's position within the automotive industry by comparing it against its top competitors. Next, chapter five examines the key components of Toyota's production system: the SMED program, Jidoka, Gradual Elimination of Muda (Kaizen, Root Cause Analysis 5why's, and Poka-Yoke), Cross-trained workers, Just-in-time production, and Heijunka. This report concludes in chapter

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

with chapter six with an analysis of Toyota's supply chain structure. This chapter specifically focuses on the impact of Toyota's Production system on its supply chain.

Chapter 2. Literature Review

Ohno, Taiichi. Toyota Production System. Portland, Oregon: Productivity P, 1978. 17.

Ohno 1978 thoroughly explains the development of each component of the Toyota production system from the vantage point of Toyota's chief production engineer. The book illustrates how the Toyota production system enables Toyota to reduce cost by improving productivity with human effort and innovation.

Jones, Daniel T., Daniel Roos, and James P. Womack. The Machine That Changed The World. New York: Harper Perennial, 1991. 149-150.

This book is based on the Massachusetts Institute of Technology's five-million dollar, five year study on the future of the automobile. Jones et al 1991 offers landmark analysis on the global move from mass production to lean production. The study is based on the practices of over ninety auto assembly plants in seventeen countries and their interviews with individual employees, scholars, and union and governmental officials. Lastly, this book shows how lean production has been allowing Toyota to achieve superior performance concurrently in manufacturing, product development, and suppliers' management.

Ochoa, Miguel. "The Toyota Production System: a study of its components." Diss. Massachusetts Institute of Technology, 1997.

Ochoa's thesis on the components of the Toyota production system offers information on the Kanban process, rules, and benefits. Ochoa's analysis provides a thorough explanation of the mechanics of the just-in-time production system used at Toyota.

Toyota Annual Report. 2 Feb. 2005
<http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

Toyota's annual report presents key information on historical revenues, operating margins, company goals, and future strategies. This report shows Toyota's organizational structure, products and services, sales channels, and customer segments.

Standard and Poors Industry Survey Autos & Auto parts. 15 Mar. 2005
<http://www.standardandpoors.com>.

Standard and Poors provides a wide variety of information on over 50 major domestic industries. Specifically, insight can be gained on industry trends and drivers and company supply chain structure.

Hoovers. 3 Feb. 2005
<http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

Hoovers.com is a database that comprises of over 12 million companies, providing up-to-date and comprehensive information pertaining to company, industry, and market intelligence. This is a good source to evaluate top competitors within industries and historical data on companies.

Chapter 3. Automotive Industry Overview

3.1. Definition Including Products and Services

The automobile industry, the business of producing and selling self-powered vehicles, includes complete passenger automobiles, trucks, commercial cars and buses, and special purpose motor vehicles. By enabling consumers to commute long distances to work, shopping, and entertainment, "the auto industry has encouraged the development of an extensive road system, made possible the growth of suburbs and shopping centers around major cities, and played a key role in the growth of ancillary industries, such as the oil and travel businesses. The auto industry has become one of the largest purchasers of many key industrial products, such as steel. The large number of people the industry employs has made it a key determinant of economic growth."[17]

Products and services offered by the automotive industry usually include car and truck models, financial services, and other miscellaneous ventures. To illustrate the structure of a typical automobile company, I will use the Ford model. Ford was one of the first carmakers to mass produce vehicles. Ford's structure and manufacturing techniques were copied by countless automobile manufacturers around the world in the first half of the 20th century – when the automobile industry was a fledging industry. Ford Motor Company, the second largest car manufacturer in the auto industry, is compromised of brands that include Aston Martin, Ford, Jaguar, Lincoln, Mercury, Volvo, Taurus, and F-Series pickup. Each car model in the automobile industry is further

[17] Answers, 1 Mar. 2005 <http://www.answers.com/automotive%20industry>.

classified as a vehicle type depending on size. The following table (Table 1) represents Ford's 2004 sales by vehicle type:

Table 1: Ford's vehicle sales

2004 Sales by Vehicle Type % of Total	
Cars	
Small	**10**
Medium	**9**
Premium	**7**
Large	**5**
Trucks	
Full−Size pickup	**28**
SUV	**27**
Bus/van	**9**
Compact pickup	**5**
Total	**100**

Table 1[18]

[18] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

Ford's finance subsidiary, Ford Motor Credit, is the US's #1 auto finance company as a result of its financing, leasing, and vehicle protection. In today's automobile industry, the majority of automakers rely on their finance subsidiary as a lone source of profit. As for miscellaneous ventures, Ford owns the Hertz Corporation. Several automakers branch out into a plethora of miscellaneous ventures that range from car rental organizations to part suppliers. The following table (table 2) represents the Ford's 2004 sales according to products and operations:

Table 2: Ford's 2004 sales according to products and operations

2004 Sales (Products and Operations)		
	$ Mil.	**% of Total**
Automotive	147,134	86
Financial services		
Ford Credit	17,404	10
Hertz	6,681	4
Other	433	–
Total	171,652	100

Table 2[19]

[19] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

3.2. Historical Revenues, Operating Margins, and Employees

Global vehicles sales flourished in the mid-to-late 1990's. However, sales growth since 2000 has stagnated at about one percent a year. The following diagram (Figure 1) is from an Accenture study on the automotive industry illustrating global light vehicle sales growth since 1991:

Figure 1: Global light vehicle sales growth

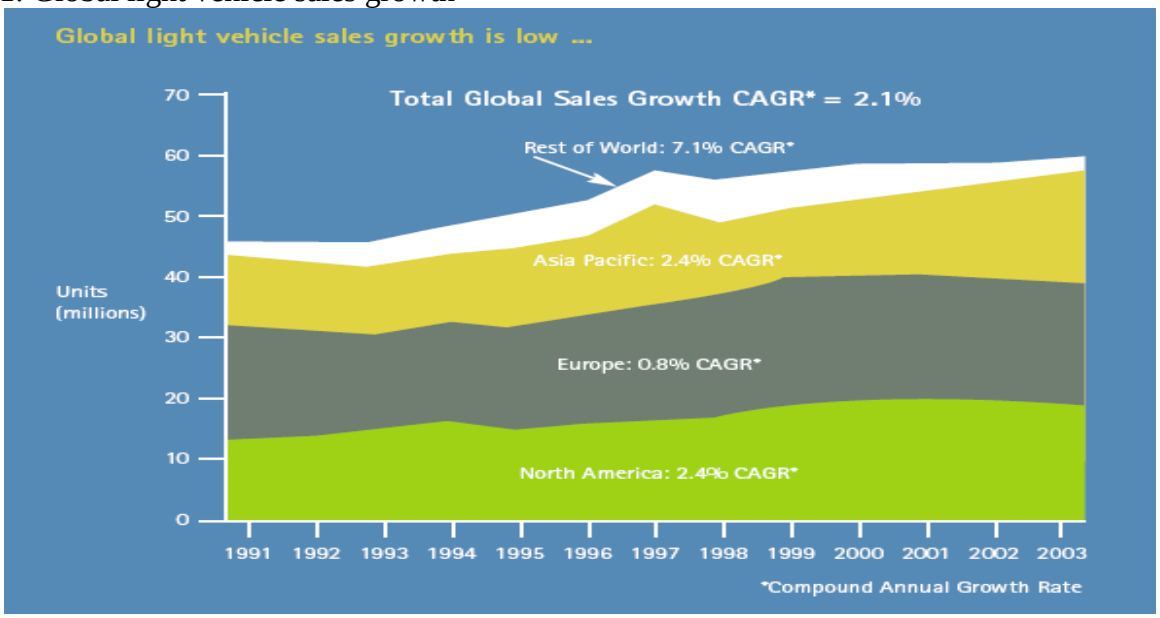


Figure 1[20]

In respect to profit margins, the automotive industry produced a net profit margin of 2.58%, return on assets of 1.6%, and a gross profit margin of 27.39%. In particular, the 'Big Three' (General Motors, Ford, DaimlerChrysler) of the U.S. automotive industry have struggled in comparison to the top Asian manufacturers (Toyota, Nissan, Honda) to make money. The majority of the productivity gaps have closed between the Big Three assembly plants and the assembly plants in North America that produce cars for Toyota,

[20] Richard D. Spitzer, Accenture, 4 Mar. 2005 <http://www.accenture.com/xdoc/en/industries/products/automotive/track/hiperf_auto.pdf>.

Honda Motor Co., and other overseas manufacturers. According to the Harbor report, which measures productivity, "the gap between GM and Toyota's North American plants is now less than four hours per vehicle, less than half the gap of only five years ago. Ford and Chrysler are also making productivity gains, with Chrysler passing Ford in the most recent rankings."[21] In past years, both GM and Ford have lost money on their core operations placing a large dependence on their finance units to be profitable. Additionally, the big three experience competitive problems because of their large base of retirees and their families.

The following table (Table 3) lists operating margins and employment information for the automotive industry.

Table 3: Automotive Industry Profits/Employment Information

Automotive Industry (Global)		**United States Figures**	
Profitability		**Annual Revenues (US)**	**$802 Billion**
Net Profit Margin	**2.58%**	Percent of Total Workforce	**3.4%**
Return On Assets	**1.6%**	Direct Employment	**1,338,700.00**
Gross Profit Margin	**27.39%**	Auto Related Employment	**2,162,419.00**
Operations		Auto Dependent Employment	**6,638,100.00**
Inventory Turnover	**8.2**	Wages	**11.5 billion**

Table 3[22]

The automotive industry comprises 3.4% of the total workforce in the United States. In a landmark study entitled *Contribution of the Automotive Industry to the U.S. Economy*, prepared by the University of Michigan and the Center for Automotive

[21] Cris Isidore, CNN, 10 Jan. 2005, 4 Mar. 2005 <http://money.cnn.com/2005/01/09/pf/autos/autoshow_walkup/>.

[22] Wards, 14 Feb. 2005 <http://www.wardsauto.com>.

Research, it was found that one out of every ten jobs in the U.S. is dependent on the automotive industry.[23] Moreover, no other industry produces more retail business and employment while being linked to U.S. manufacturing. Direct employment (including: production workers, engineers, designers, sales and marketing employees and other corporate staff) for the United States is 1,338,700. Auto related employment (including: suppliers of parts and components, suppliers of raw materials, and support services such as advertising and engineering consultants) in the United States is 2,162,419. Auto Dependent Employment (including independent repairers, vehicle shipping services, the aftermarket industry, car wash employees, tow truck drivers, rental car employees and other employment that is dependent on the auto industry) is 6,638,100.

3.3. Evolution of Top 5 Companies

General Motors (GM)

In 1908, General Motors was formed from a conglomeration of carmakers by William Durant, owner of Buick Motors, in Flint Michigan. By 1915, the General Motors Acceptance Corporation (GMAC, financing) included Chevrolet, Oldsmobile, Cadillac, Pontiac, and others. Under the leadership of Alfred Sloan (president, 1923-37) General Motors became a corporate colossus through the use of a decentralized management system. Under this system, General Motors offered a plethora of models and colors, which was a sharp contrast from industry leader Ford who only offered cars in black. This propelled General Motors to the top of the automotive industry in 1927.

[23] Alliance of Automanufacturers, 12 Mar. 2005 <http://www.pittsburghmultimedia.com/auto>.

From 1925-1935, General Motor's notable activity include buying Vauxhall Motors (UK, 1925), merging with Adam Opel (Germany, 1931), adding defense products for WWII, and diversifying into home appliances and locomotives.[24]

During the 1970's GM spent much of the decade trying to emulate the Japanese's manufacturing techniques, which led to the formation of New United Motor Manufacturing (NUMMI) in 1984 with Toyota. From 1984-1986, General Motors increased its stake in Saab Automobile, and bought Electronic Data Systems and Hughes Aircraft. In 1999 General Motors and Honda reached a deal where Honda would supply V6 engines and transmissions for GM, while Isuzu Motors, a GM affiliate, supplies Honda with diesel engines. During the next two years, GM bought the rights to the Hummer brand from AM General, acquired the 50% of Saab Automobile that it didn't already own from Investor AB, and acquired a 20% stake in Fiat Auto in exchange for a 5.6% Fiat stake in GM. Lastly, General Motors acquired a 20% stake in Fuji Heavy Industries (Subaru) in 2000.[25]

In 2001, General Motors increased its stake in Suzuki to 20% and took over Daewoo Motor after submitting a bid for $776 million. Early in 2003 General Motors sold its defense units (armored vehicles) to General Dynamics for $1.1 billion. 2004 marked the last model year for GM's Oldsmobile brand that the company bought nearly 100 years earlier. In late 2004, General Motors became the first Western car company to

[24] Hoovers, 12 Feb. 2005
<http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10640>.
[25] Hoovers, 12 Feb. 2005
<http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10640>.

offer automotive loans to Chinese consumers through a joint venture with Chinese partner Shanghai Automotive Industry Corp.[26]

Today, General Motors is the world's largest maker of cars and trucks. Its brands include Buick, Cadillac, Chevrolet, GMC, Pontiac, Saab, and Saturn. General Motors also produces cars through its Holden, Opel, and Vauxhall units. Other operations include Allison transmission (heavy-duty automatic transmissions), and GM Locomotive (locomotives, diesel engines). GM also has stakes in Isuzu Motors, Fuji Heavy Industries (Subaru), Suzuki Motor, and Fiat (Alfa Romeo, Lancia). Subsidiary GMAC provides financing.[27]

Ford

Ford Motor Company was started in 1903 in Dearborn, Michigan by Henry Ford. Based on the success of the inaugural car, the Model T, Ford produced 60% of the vehicles that were on the road in the United States in 1920.[28] In 1922 Ford purchased Lincoln. Edsel Ford, Henry Ford's son, became president in 1932 and introduced the Model A that replaced the Model T. In 1943, Edsol's son, Henry II, took over and decentralized Ford, following the GM model. By 1950, Ford recaptured second place in the industry and launched the Mustang.

---

[26] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10640>.
[27] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10640>.
[28] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

Ford added luxury sports cars in 1987 through acquiring 75% of Aston Martin, and bought the rest of the brand in 1994. Moreover, in the same year Ford acquired Hertz rental car and then bought Budget Rent a Car. By 1996 Ford increased its stake in Mazda to one-third.[29] In 1997, Ford beat General Motors in the race to produce vehicles for the Chinese market by building a minibus line in China.[30] In 1998 Ford acquired Cosworth's racing-engines unit from Audi and sold off its direct stake in Kia Motors, but kept an indirect stake through its interest in Mazda. Henry Ford's great-grandson, William Clay Ford Jr., became chairman in 1998.

Ford is the world's second largest producer of cars and trucks, behind General Motors. Ford is compromised of brands that include Aston Martin, Ford, Jaguar, Lincoln, Mercury, Volvo, Taurus, and F-Series pickup. Ford has purchased BMW's Land Rover SUV operations and owns a controlling thirty-three percent stake in Mazda. Ford's finance subsidiary, Ford Motor Credit, is the US's #1 auto finance company. The Ford family owns a little over 40% of the company's voting stock.[31]

[29] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.
[30] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

[31] Hoovers, 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

DaimlerChrysler

DaimlerChrysler's origin dates back to 1920's when Walter Chrysler, then President, renamed Maxwell Motor Car Company after himself and introduced the Chrysler. The company acquired Dodge in 1928, and introduced the Plymouth and the more luxurious DeSoto in the same year.[32] Despite other car manufacturers perpetually modifying styles based on consumer demand, Chrysler kept the same models from 1942 until 1953. This misapprehension of demand caused the company to lose market share for several decades.

In 1926 Daimler-Benz, Chrysler's acquirer, was formed by the merger of two German motor companies: Daimler and Benz. The company's Mercedes cars gained notoriety and sales expanded worldwide in the 1970s. Daimler-Benz diversified in the 1980s through the acquisition of aerospace, heavy truck (Freightliner), and consumer and industrial electrical companies. Future losses at its aerospace unit forced Daimler-Benz into the red in 1995. Also, in the same year Daimler-Benz and Asea Brown Boveri (ABB) formed the joint venture Adtranz, which turned into the #1 train maker in the world.[33]

In 1998 Daimler-Benz acquired Chrysler and introduced 'The Smart' compact car in Europe. DaimlerCrysler combined both companies' financial service units into DaimlerCrysler Interservices (DEBIS) in 1999. In 2000 DaimlerCrysler agreed to buy a

[32] Hoovers, 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.
[33] Hoovers, 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.

controlling $2.1 billion stake of thirty-four percent of Mitsubishi Motors. On a bad note, "billionaire investor Kirk Kerkorian filed an $8 billion lawsuit in 2000, seeking to undo the Daimler-Benz/Chrysler merger on the grounds that portraying the deal as 'a merger of equals' was misrepresentative." [34]

In 2004 DaimlerChrysler received Chinese regulatory approval to build cars in China with joint venture partner Beijing Automotive Industry Holding Co. Ltd. (BAIC). The venture plans to build as many as 25,000 C- and E-class Mercedes cars annually.[35]

DaimlerChrysler is the world's third largest carmaker in sales behind General Motors and Ford. The company makes an astounding 4.3 million vehicles a year. Chrysler's brands include Dodge, Jeep, and Chrysler's vehicles. The Mercedes Brands includes luxury Sedans, commercial vehicles, and SUVs. Moreover, DaimlerChrysler's Freightliner unit is the US's top heavy-truck maker. DaimlerChrysler also has a twenty percent stake in Mitsubishi Motors, and a 33% stake in European Aerospace and Defense consortium (EADS).[36]

[34] Hoovers, 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.
[35] Hoovers, 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.
[36] Hoovers, 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.

Toyota

The Toyota that we know today originated from a department within the Toyoda Automatic Loom Works Company founded by Sakichi Toyoda in 1926. After selling his automatic loom patent rights in 1937, Sakichi used the proceeds to finance an automobile manufacturing operation that his son Kiichiro Toyoda set to manage.[37] Eager to see the family's new venture succeed, Kiichiro Toyoda spent a year at the Ford Motor company in Detroit studying the automotive industry. Upon return to Japan, it was Kiichiro's goal to adopt a more sleek version the Ford production system that will accommodate smaller production quantities at Toyoda. Moreover, Kiichiro's sought to implement a system that provided for different processes in the assembly sequence of production, the logistics of material simultaneous to production consumption, and a supplier network capable of supplying component material as required. This system was referred to as the Just-in-Time (JIT) within the Toyoda Group.[38]

Eiji Toyoda, the nephew of Sakichi, joined the Toyoda Automatic Loom Works family business in 1936, and was named managing director of the Toyoda Automotive works in 1950. During his first year as manager, Eiji followed his uncle's footsteps and traveled to the United States to study the American automotive industry. Upon his return to Japan, Eiji incorporated what is now referred to as one of the major building blocks of the Toyota Production System – continuous improvement (Kaizen).[39] Eiji adopted the concept of continuous improvement from the Ford Motor company suggestion system. Eiji reamed the Toyoda automotive operation The Toyota Company in 1957, and again in

[37] Becker, Ronald M. (2005), "Lean Manufacturing and the Toyota Production System," http://www.sae.org/topics/leanjun01.htm
[38] Ibid.,1.
[39] Ibid.,1.

1983 to the Toyota Motor Corporation. In 1982, he established the Toyota Motor Sales USA.[40]

Taiichi Ohno joined Toyoda Automatic Loom Works in 1932, and is credited with creating what is known as the Toyota Production System. He is also considered the father of the Kanban system. Taiichi Ohno played a major role in establishing the JIT principles and methodologies developed in the Loom manufacturing process that was later transferred to Toyoda's automobile operation. Ohno acknowledges two concepts that facilitated the development of the Toyota production system. The first concept was adapted from Henry Ford's book *Today and Tomorrow* published in 1926 provided the basis of a manufacturing production system. The second concept was the supermarket operations in the United States, which provided the foundation of a continuous supply of materials as the supermarket provided a continuous supply of merchandise on the store shelves.[41] Other notable figures that helped shape Toyota's production system included: Shigeo Shingo who "assisted in the implementation of quality initiatives; and Edward Deming who brought statistical process control to Japan."[42]

Toyota is now regarded as one of the highest quality automakers in the world because of its' continuous improvement process. It is Japan's largest and the world's 4th largest carmaker by sales (after General Motors, Ford, and Daimler Crysler). Toyota makes a hybrid powered (gas and electric) Sedan – the Prius, which is popular in Europe and the United States. Its gas powered cars, pickups, minivans, and SUVs include such models as the Camry, Celica, Corolla, 4Runner, Echo, Land Cruiser, Sienna, the luxury

[40] Ibid.,1.
[41] Ibid.,2.
[42] Ibid.,2.

Lexus line, and a full sized pickup truck, the V-8 Tundra. Toyota also makes forklifts and manufactured housing, and offers consumer financial services.[43]

Honda

Honda Motor Co. in started in the late 1940s producing motorcycles. Soichiro Honda, its founder, already had a reputation in the industry from his patented metal spokes that replaced wood in wheels. American Honda Motor Company was formed in Los Angeles in 1959, and Honda added overseas factories in the 1960s and began producing lightweight trucks, sports cars, and minicars.

In 1970, the company began selling its 600 model in the US, but it was the Civic, introduced in 1973, that scored with the US car market. The introduction of the Accord in 1976 featured an innovative frame adaptable for many models.[44]

In 1999 Honda and GM signed a deal in which Isuzu, a GM affiliate, would supply Honda with diesel engines, while Honda would supply GM with low-emission V6 engines and automatic transmissions.[45] In 2001 Honda Research and Development division announced its plan to set up a solar-powered hydrogen production station in California as part of its efforts to develop renewable-energy fuel cell vehicles.

Honda is Japan's third largest automaker and the world's largest motorcycle producer. Honda's car models include the Accord, CR-V, Civic, Element, Passport, Acura, and the Insight – its gasoline/electric hybrid. The company has a power products

[43] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41889>.
[44] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41867>.
[45] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41867>.

division that produces commercial and residential-use machinery (lawn mowers, snowblowers), portable generators, and outboard motors.

3.4. Customer Segments and Sales Channels

Typically, manufacturers section their sales channels into regions. Toyota, for example, has three main regions consisting of Japan, North America, Europe, and a fourth region that is classified as 'other' comprising all of the smaller markets. Customer segments can range from governments to distributors and end-consumers.

3.5. Industry and Supply Chain Structure

The automotive industry supply chain is divided into three main parts: Original Equipment manufacturers (OEMs), first tier suppliers, and second tier suppliers. Examples of OEM's include Toyota, General Motors, and Ford. Today, OEMs focus on parts and services which they have a clear competitive advantage and are outsourcing other work to suppliers. The first tier of the supply chain consists of several hundred companies. First tier suppliers can produce anything ranging from an individual part for a major system or as integral as the entire axle assembly. Many first tier suppliers are increasing their input into designing and manufacturing complete modules or systems for OEMs rather than just building parts. Often First tier suppliers usually work for multiple OEMs. For example, TRW conducts 23 percent of its business with Ford and 10 percent with General Motors.

Second tier suppliers are composed of thousands of smaller companies that work with OEMs only indirectly via other suppliers. An exception would be a first tier supplier who also operates on the second tier by supplying parts to rivals on the first tier.

Second tier suppliers are relatively smaller companies that supply components or modules to first tier suppliers without having much interaction with OEMs. Third tier suppliers are usually second tier suppliers supplying parts to a rival second tier supplier. The following figure (figure 2) illustrates the typical supply chain structure for the automotive industry:

Figure 2: Supply chain structure in the automotive industry

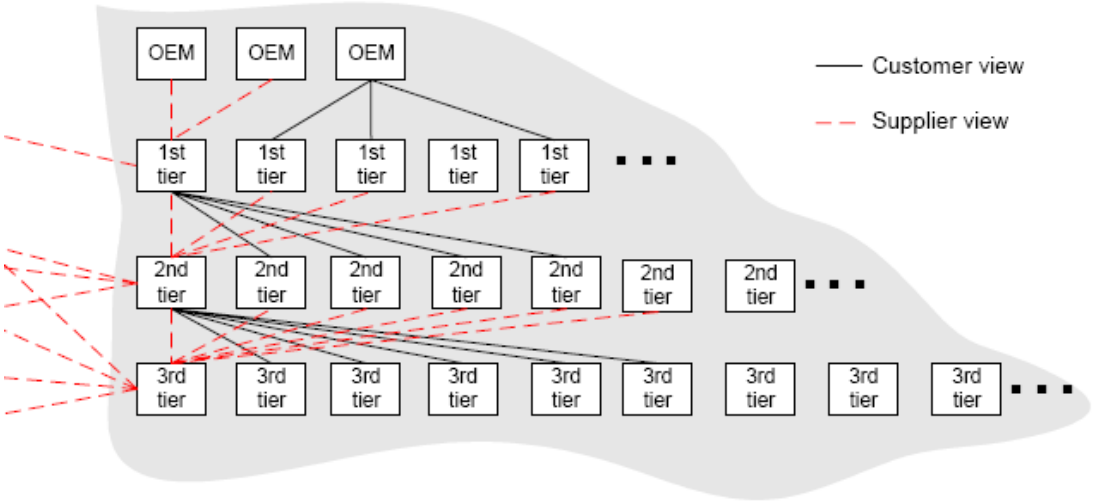


Figure 2[46]

[46] Jonathan Morell, Ph.D; Thomas A. Phelps, Ph.D. A Review of Interoperability Issues In the Automotive Industry 15 Feb. 2005 < http://www.jamorell.com/Jonny/web_new/nacfam-7_a.pdf>.

3.6. Trends and Drivers

The two main drivers in the automotive industry involve increasing return on assets and cost reduction. Efforts to increase return on assets has driven the industry to produce such noticeable trends as reducing the cost of procurement, better collaborating and coordination with suppliers, and optimizing the supply chain network. In attempt to increase return on assets, automakers are now outsourcing more of what used to be done in-house to their largest suppliers.[47] First tier suppliers have increased responsibility for subassembly work and quality testing. This trend has led to closer interaction between supplier and manufacturer in the design development and engineering components and systems. This allows manufacturers to focus on their core competence such as: marketing, engineering, and production expertise. In addition to procuring more from suppliers, Automakers and suppliers collaborate and coordinate activities in a more efficient manner. Typically, manufacturers interact daily with their first tier suppliers. It is not rare to see personnel from manufacturers at supplier's sites and vice versa. OEM's and suppliers must work together to find equitable solutions to improve both value and profitability. Manufacturers and suppliers are now located within close proximity of one another in order to reduce transportation costs throughout the supply chain.

Attempts by manufacturers to lower costs have produced trends such as supplier consolidation, and lower development costs. Vehicle manufacturers are attempting to reduce the number of suppliers they utilize, in order to trim costs and increase efficiency. This has manifested in mergers and acquisitions of first and second tier suppliers. It was noted in a recent study by PricewaterHouseCoopers that by 2010 global tier 1 suppliers

[47] Standard and Poors Industry Survey Autos & Auto parts, 15 Mar. 2005 <http://www.standardandpoors.com>.

will reduce from 800 to 35, and tier 2 suppliers from 10000 now to 800.[48] Efforts to reduce development costs have led to increased focus on the delivery of complete systems and platform structures. The platform concept is becoming increasingly important as automakers seek to reduce costs by designing and producing more vehicles from common platforms. The number of platforms is an important measure of annual design and engineering effort of each company. Most automakers are now pursuing a strategy of reducing the number of platforms but increasing their flexibility and the number of models that can be developed from each platform. This strategy offers consumers more model strategy while reducing design and development costs. Combined with lower unit R&D costs, platforms and complete systems will drive the industry towards greater economies of scale. Consequently suppliers are reconfiguring their assets around systems and platforms rather than individual components.

[48] Pricewaterhouse Cooper, 21 Feb. 2005 <http://www.pwcglobal.com/Extweb/pwcpublications.nsf/docid/4EFBA3D2E36509CC85256BDE006BEC7B>.

Chapter 4. Toyota's Position in Automotive Industry

Toyota is the world's 4th largest car manufacturer by sales behind General Motors, Ford, and Daimler Chrysler.[49] Toyota's management philosophy of contributing to people's lifestyles and society through automotive manufacturing has driven the company to expand into new regions that include Central and Eastern Europe, India, Russia, China. Toyota has experienced enduring success thanks to its combination of world-leading manufacturing, rapid product development, and devotion to customer satisfaction.

In terms of world-leading manufacturing, Toyota taught the modern car industry how to make cars properly. Not many had heard of the Toyota production system until three academics, who were a part of the car industry study program, at Massachusetts Institute of Technology (MIT) wrote a book in 1991 called *The Machine that Changed the World*. The book describes the principles and practices behind the just-in-time manufacturing system. At the core of Toyota Production System is *Kaizen*: elimination of waste and absolute concentration on consistent high quality by a process of continuous improvement.[50] Car manufacturers have rushed to embrace and adopt the principles of Toyota's Production System. During this process, American and European cars went from being unreliable, with irritating breakdowns, leaks and bits dropping off in the 1970s, to the sturdy, reliable models consumers take for granted today.[51]

---

[49] Hoovers, 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41889>.
[50] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 149-150.
[51] Economist, 27 Jan. 2005, 2 Apr. 2005 <http://www.economist.com/business/displayStory.cfm?story_id=3599000>.

Like its word-leading manufacturing, Toyota's rapid product development is another source of success. Toyota's product-development process can roll out new models in less than two years.[52] This enables Toyota's bosses counter rivals quickly once they spot a gap in the market or a smart new product.

Additionally, Toyota's devotion to customer service has manifested into a culture known as the "Toyota Way." In a recent article from the economist noted that "while the rest of the car industry raves about engines, gearboxes, acceleration, fuel economy, handling, ride quality and sexy design, Toyota's people talk about "The Toyota Way" and about customers."[53] Banners can be found within factories reminding workers of this goal. Toyota's focus on customer service seems to have been absorbed by Japanese, European, and American employees alike.

4.1. Historical Company Revenues, Operating Margins, and Employees

Toyota's financial strategy focuses on three targets of growth, efficiency, and stability. Regarding growth, Toyota feels that forward-looking investment is crucial to ensure growth of their operations and earnings. Toyota sees capital expenditures and research and development as key drivers of sustained future growth. Toyota's views sacrificing long term growth in order to boost short-term profits as an inappropriate

[52] Economist, 27 Jan. 2005, 2 Apr. 2005 <http://www.economist.com/business/displayStory.cfm?story_id=3599000>.
[53] Economist, 27 Jan. 2005, 2 Apr. 2005 <http://www.economist.com/business/displayStory.cfm?story_id=3599000>.

financial strategy for technology-driven companies in the manufacturing sector.[54] Management philosophy at Toyota emphasizes cash flows in order to steadily raise corporate value for their shareholders. In adherence with that philosophy, "Toyota undertook investments in property, plant and equipment of approximately ¥950 billion (excluding vehicles and equipment on operating leases) and recorded roughly ¥680 billion in research and development expenses in fiscal 2004."[55]

With respect to efficiency, Toyota is committed to enhancing capital efficiency by taking decisive steps to improve profitability. In fiscal 1999, Toyota posted an operating income margin of 6.0% and a ROE of 6.8%. A clear indication of the company's pursuit of growth and efficiency is their operating income margin of 9.6% and ROE of 15.2% in 2004, which surpassed medium-to-long term targets of 9% and 10%.[56] Executive Vice President Ryuji Araki believes that "Toyota's concerted effort to enhance profitability through stepped-up cost reductions and other initiatives have resulted in substantial growth in income when compared with increases in assets and capital."[57]

Concerning stability, Toyota strives to maintain a solid financial base by ensuring abundant liquidity and stable shareholders' equity. Toyota views that a sound financial foundation is needed to enable continued flexible, forward-looking investment even during sharp fluctuations in operating and market environments. Toyota has invested massive amounts of capital in the creation of new earnings opportunities by expanding financial services operations, globalizing operations, and investing in research and

[54] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.
[55] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.
[56] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.
[57] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

development.[58] Further, Toyota has been able to while keeping cash levels relatively low. Toyota's philosophy is that the balanced advancement of those three key financial strategies will help realize sustainable, stable long term growth of the company and shareholder value.[59]

[58] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.
[59] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

In 2004 worldwide vehicle sales reached 6.71 million units, and net revenues were over ¥17,294,760 million. This was an astounding 11.6% change from 2003. Toyota employs over 264,410 people worldwide, and posted a profit margin of 6.7% as a result of its financial strategy. [60] The following diagram (Figure 5) illustrates Toyota's growth in net revenues over the past 5 years:

Figure 3: Toyota Net revenues

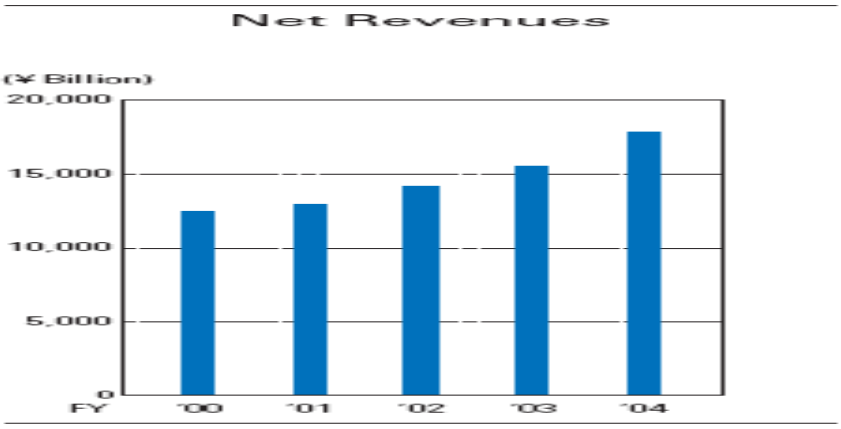


Figure 3[61]

[60] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.
[61] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

4.2. Business Units

Toyota's is segmented by actual automotive sales, financial services (leasing, vehicle protection, financing), and other ventures (manufactured housing, forklifts, etc.). The following table (Table 4) lists Toyota's business units:

Table 4 : Sales by segmentation

2004 Sales	$ mil	%
Automotive	$151,037	92%
Financial Services	$6,781	4%
Other ventures	$5,819	4%
Total	$163,637	100%

Table 4[62]

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

4.2. Products and Services

Toyota makes a hybrid powered (gas and electric) Sedan – the Prius, which is popular in Europe and the United States. Its gas powered cars, pickups, minivans, and SUVs include such models as the Camry, Celica, Corolla, 4Runner, Echo, Land Cruiser, Sienna, the luxury Lexus line, and a full sized pickup truck, the V-8 Tundra. Toyota also makes forklifts and manufactured housing, and offers consumer financial services (financing, leasing, vehicle protection).[63] The following table (Table 5) lists every product and service offered by Toyota:

Table5: Toyota Products and Services

Toyota's Products and Services	
Selected Models □	**Type; Location Site**
4Runner	SUV, Latin America and North America
Avalon	Full−sized sedan; Asia, Middle East, North America, and Oceania
Camry	Midsized sedan; Africa, Asia, Europe, Latin America, Middle East, North America
Camry Solara	Midsized coupe; North America
Celica	Sports car; Asia, Europe, Latin America, North America, and Oceania
Corolla	Compact sedan; Africa, Asia, Europe, Latin America, Middle East, North A.
Echo	Compact coupe; North America
Highlander □	SUV, North America
Hilux	Pickup truck; Africa, Asia, Europe, Latin America, Middle East, and Oceania
Land Cruiser	SUV; Africa, Asia, Europe, Latin America, Middle East, North America
Lexus	Luxury sedan
MR2 Spyder	Sports car; Asia, Europe, Middle East, North America, and Oceania
Prius	Gas/electric hybrid compact sedan, Asia, Europe and North America
RAV4	SUV; Africa, Asia, Europe, Latin America, Middle East, North America Oceania
Sienna	Minivan, North America
Tacoma	Pickup truck, North America
Tundra	Pickup truck, North America
Other Products □	
Factory automation equipment	
Forklifts and other industrial vehicles	
Housing products	

Table 5[64]

The following table (Table 6) lists the various investments undertaken by Toyota:

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

Table 6: Toyota Investments

Selected investments	
Crest Homes	98%, prefabricated homes
Daihatsu Motor	51%, motor vehicles
Hino Motors Ltd.	50%, trucks
Life Creation Co., Ltd.	40%, camping facilities
Tacti Corporation	80%, retail auto parts
Toyota Epoch Life Co., Ltd.	95%, off−road driving instruction
Toyota Mizunami Development Co., Ltd.	38%, golf course operator

Table 6[65]

4.4. Sales Channels

Toyota operates in more than 60 manufacturing facilities in 26 countries throughout the world. Toyota's operations are sectioned into 4 channels: Japanese region, North America region, European region, and Other regions. The most profitable region is its domestic market of Japan followed by the North American region. The following table (Table 7) lists Toyota's sales channels by region:

Table 7: Toyota Sales Channels by region

2004 Sales	$ mil.	% of total	Unit sales No.(thou)	% of total
Japan	$67,818	41%	2,303	34%
North America	$55,922	34%	2,103	31%
Europe	$19,103	12%	898	14%
Other regions	$20,794	13%	1,415	21%
Total	$163,637	100%	6,719	100%

Table7[66]

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

4.5. Top Competitors and Positioning against them

The top four automotive manufacturers posted close sales number in 2004 with Toyota trailing only General Motors, Ford, and DaimlerChrysler in sales. However, Toyota experienced substantial one year sales growth in comparison with its main competitors. In regards to efficiency, Toyota was able to produce similar sales numbers with a significantly less amount of employees. The following table (Table 8) illustrates Toyota's position against its top competitors:

Table 8: Toyota's positioning against Top 3 competitors

Toyota's Positioning Against its Top 3 Competitors				
	GM	Ford	DaimlerChrysler	**Toyota**
2003 Sales (mil)	**$185,524**	**$164,196**	**$171,529**	**$163,637**
1-year Sales growth	**0.7%**	**0.5%**	**9.2%**	**26.9%**
2003 Net Income (mil)	**$3,822**	**$495**	**$562**	**$10,995**
2003 Employees	**326,000**	**327,531**	**362,063**	**264,410**
1-year Employee growth	**6.9%**	**6.5%**	**1%**	**0.1%**

Table 8[67]

In respect to profit margins, Toyota is outpacing almost everyone in the automotive industry (see figure profit diagram). This makes Toyota the exception in the automotive industry when it comes to making a real return on its capital. Since 2000, the output of the global industry has risen by about 3 million vehicles to some 60 million. Of

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

that increase, half came from Toyota alone. Here is a list of some of Toyota's financial highlights for 2004:

- **Vehicle sales:** up 9.9%, to 6.71 million (an all-time high)
- **Vehicle production:** up 11.3%, to 6.51 million (an all-time high)
- **Net revenues:** up 11.6%, to ¥17.29 trillion (an all-time high)
- **Operating income:** up 31.1%, to ¥1.66 trillion (an all-time high)
- **Net income:** up 54.8%, to ¥1.16 trillion (an all-time high)
- **ROE:** up from 10.4% to 15.2%
- **Net income per share:** up 62.3%, to ¥342.90
- **Annual cash dividends per share:** up ¥9.00, to ¥45.00
- **Shareholders' equity:** up 14.9%, to ¥8.17 trillion
- **Total assets:** up 9.4%, to ¥22.04 trillion

The following Figure (Figure 4) displays Toyota's profit margins in comparison with its competitors:

Figure 4: Toyota Profit Margin

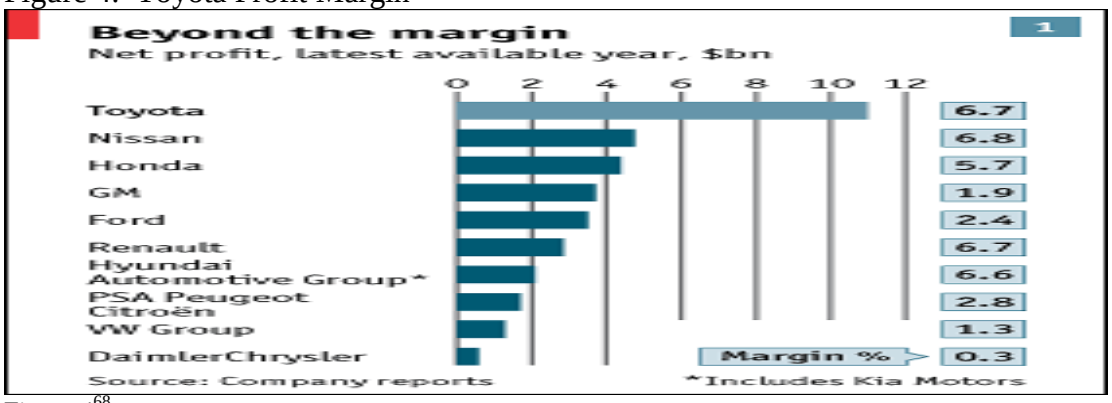


Figure 4[68]

Chapter 5. Toyota Production System

5.1 Gestation of Toyota Production System

In thirteen years of effort, the Toyota Motor Company had, by 1950, produced 2,685 automobiles in comparison to the 7,000 automobiles that Ford's Rouge plant, in

[68] Toyota Annual Report, 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

Detroit, Michigan, poured out in a single day.[69] The disparity in production prompted Toyota's top manager, Eiji Toyoda, and several of his engineers to visit the Rouge plant in attempt to learn how to improve their manufacturing processes. Taiichi Ohno and Shigeo Shingo are two of the most notable engineers who visited the Rouge plant. Taiichi Ohno, Toyota's chief production engineer, joined the company out of high school in 1932, and is considered to be the creator of the just-in-time production system. Shigeo Shingo is regarded as one of the world's leading experts in improving manufacturing processes. He is known for his ability to understand why products are manufactured the way they are, and then transforming that understanding into a workable system for low cost, high quality production.[70]

Toyota set out to become full range car producers with a variety of new models. After Eiji Toyoda and his engineers separate visits to the Rouge plant, they concluded that simply copying and improving the Rouge would not work in Japan for several reasons. One reason is Toyota was in poor financial condition. Japan was recovering from the ill-effects of War World II, which left the country starved for capital and for foreign exchange.[71] This meant, that Toyota could not afford to buy the latest Western production technology if they desired, because they did not have the resources to invest in large expensive new machinery that was believed to be needed to improve production efficiency.

---

[69] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 48.
[70] Quality Coach: Shigeo Shingo, 13 Mar. 2005 <http://www.qualitycoach.net/shingo.htm>.

[71] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 48.

One of the pillars of the mass production system used in the West is that you can reduce the cost of products by making everything in a standardized form and at high volume. Dissimilar to the West, the domestic market in Japan is tiny and demanded a wide range of vehicles –"luxury cars for government officials, large trucks to carry goods to market, small trucks for Japan's small farmers, and small cars suitable for Japan's crowded cities and high energy prices."[72] For this reason, Toyota would not be able to meet demand in their domestic market by adopting the techniques of the mass production system.

Third, the automotive industry was led by Western companies such as Ford Motor Company and General Motors who both used mass production systems and were seeking to establish operations in Japan. Toyota's management believed that the company could gain a competitive advantage by creating their own system from techniques learned from both mass producers and craft producers.

Lastly, the position of workers in Japan strengthened with the onset of new labor laws in 1949. Consequently, bargaining positions of company unions representing all employees was greatly reinforced. Following a strike in the late 1940s, a settlement between the Toyoda family and the worker's union granted employees two guarantees: "one was for lifetime employment; the other was for pay steeply graded by seniority rather than by specific job function and tied to company profitability."[73] Workers became members of what is known as the Toyota community, which gave them the aforementioned benefits, a full set of rights, and access to Toyota facilities that included housing, recreation and so on. These privileges went far beyond what most unions had

[72] Ibid., 49.

[73] Ibid., 54.

been able to negotiate in the West. Toyota expected that most employees would remain with Toyota for their working lives. The employees also agreed to be flexible in work assignments and active in promoting the interests of the company by initiating improvements. This is a huge contrast to the Western mass production system where immigrants and minorities, with limited occupational choice, who were willing to put up with sub-standard working conditions in return for high pay, formed the core of their workforce.[74]

These were the conditions that led to the creation of the Toyota Production System – otherwise known as lean manufacturing. The Toyota production system is now widely recognized for its groundbreaking techniques as it is considered to be the next stage in development of manufacturing after mass production. The techniques used in Toyota's production system have revolutionized the way manufacturer's approach and implement production across industries. Subsequent parts of this chapter will explain the main components of Toyota's production system, which include: the SMED program, Jidoka, gradual elimination of muda (Kaizen, 5why's, Poka-Yoke), cross-trained workers, just-in-time production, and Heijunka.

5.2 The SMED Program

Western automakers established two methods of handling dies (a hard piece of metal in the exact shape the sheet metal should assume). The first method is where craft

[74] Ibid., 50.

producers, automakers who manufactured less than a few hundred vehicles a year, "cut sheets of metal to a gross shape, and then beat these blanks by hand on a die to their final shape."[75] The second method is where mass producers, automakers producing more than a few hundred cars a year, "ran metal sheets through an automated blanking press to produce a stack of flat beds slightly larger than the final part they desired. Next, they inserted the blanks in massive stamping presses containing matched upper and lower dies, which are then pushed together under thousands of pounds of pressure forming a three dimensional shape of a car fender or a truck door as it moves through a series of presses. Under this method, manufacturers produced huge batches and would change dies every two-three months."[76]

Taiichi Ohno saw many challenges with adopting one of these methods at Toyota. The method undertaken by craft producers would not allow Toyota to produce vehicles to the mass market. Additionally, Ohno felt that the difficulty with the method used by mass producers was the minimum scale required for economical operation.[77] The production lines in the West were designed to "operate at about twelve strokes per minute, three shifts a day, to make a million or more of a given par a year."[78] This was both massive and expensive in comparison to the few thousand vehicles that comprised Toyota's entire production.

The Western method of changing dies that weighed many tons posed a big challenge. Changing the dies required workers to align them in the press with absolute accuracy. The consequences of misaligned parts ranged from wrinkled parts to melted

[75] Ibid., 51.
[76] Ibid., 52.
[77] Ibid., 52.
[78] Ibid., 52.

sheet melted in the die that imposed costly and time-consuming repairs. Automakers would assign die changing specialist to avoid misalignments. Usually, die changes required a "full day to go from the last part with the old dies to the first acceptable part from the new dies."[79]

After studying the two Western methods, Ohno developed the idea of simple die changing techniques and to change dies frequently (every two-three hours versus two-three months).[80] 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. This 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:

3. "Making small batches eliminated the carrying cost of the huge inventories of finished parts that the mass production system required.
4. Making only a few parts before assembling them into a car caused stamping mistakes to show up almost instantly."[81]

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

[79] Ibid., 52.
[80] Ibid., 52.
[81] Ibid., 52.

program offered tremendous cost reductions through reduced inventory, and improved quality.

5.3 Jidoka (Highlight Problems)

In the mass production system, workers usually performed one or two tasks repeatedly under the guidance of a foreman. The foreman directed the efforts of the assembly workers, but did not perform any assembly tasks. Generally, factory management was graded on yield (number of cars actually produced in relation to the scheduled number) and quality (out-the-door quality after vehicles had defective parts repaired).[82] Managers discouraged workers to stop the assembly line because falling below the set production targets resulted in poor management grades for yield and quality, and time and cars lost to line stoppages could only be made up with expensive overtime at the end of a shift.[83] As a result, cars or parts that were defective were able to progress down the line with a misaligned part or some other malfunction. Defective work was rectified in the rework area by special inspectors.[84]

Jidoka direct translation in English is automation. Today, Jidoka is referred to as Autonomation, which is automation with human intelligence.[85] 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,

[82] Ibid., 55.
[83] Ibid., 55.
[84] Ibid., 55.
[85] Strategies: Jidoka and Automation, 15 Apr. 2005 <http://www.strategosinc.com/jidoka.htm>.

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

Errors have reduced drastically since Toyota first implemented the Jidoka approach in its production facilities. Today, Toyota plants produce yields that often approach 100%, meaning the line practically never stops.[86] The quality improvements that Jidoka offers allows Toyota to reduce cost by saving on repairs, and increase their brand reputation as a high quality automotive manufacturer.

5.4 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 Kaizen, Root-Cause analysis, and Poka-Yoke.

5.4.1 Kaizen (Continuous Improvement)

[86] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 57.

Kaizen is a Japanese term for incremental improvement process. Taiichi Ohno was inspired to implement Kaizen at Toyota 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.[87] 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, employees are able to identify opportunities for improving their jobs. Through Kaizen, Toyota creates ownership for workers to maintain standard work. In 2001, Toyota received over 100,000 improvement suggestions from employees, 98% of which were used resulting in a savings of $18,000,000, and returned $3,000,000 for individual awards of $25 to $25,000.[88]

5.4.2 Root Cause Analysis 5Why's

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.[89] 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."[90] 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

[87] Ibid., 149.
[88] TWI: Kaizen, 12 Apr. 2005 <www.tdo.org/twi/TWI.ppt>.

[89] Taiichi Ohno, Toyota Production System (Portland, Oregon: Productivity Press, 1978) 17.
[90] Ibid., 18.

causes of a problem. It can be learned quickly and doesn't require statistical analysis to be used.[91] The following example, taken from Taiichi Ohno's book *Toyota Production System*, outlines the purported response to a machine that stopped functioning:

1. Why did the machine stop?

There was an overload and the fuse blew.

2. Why was there an overload?

The bearing was not sufficiently lubricated

3. Why was it not lubricated sufficiently?

The lubrication pump was not pumping sufficiently.

4. Why was it not pumping sufficiently?

The shaft of the pump was worn and rattling.

5. Why was the shaft worn out?

There was no strainer attached and metal scrap got in.

Like many of the aforementioned techniques, root cause analysis through implementation of the 5Why's encourages Toyota's workers to be proactive in the production process. This approach towards problem solving improves quality, worker skill levels, and reduces cost by deterring errors from multiplying.

5.4.3 Poka-Yoke (Fool Proofing)

[91] Doug William and Associates: 5whys, 22 Mar. 2005 <http://www.dwassoc.com/5-whys.php>.

Shigeo Shingo is credited for coming up with the idea of Poka-Yoke. Poka-Yoke in the automotive industry 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."[92] The approach is to prevent mistakes before they occur in order to reduce failure. A Poke-Yoke device is one that prevents incorrect parts from being made or assembled. An example of a Poke-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.[93] Because inspections entail minimal cost, every item may be inspected. Provided that work-in-process inventories are low, quality feedback used to improve the process can be provided very rapidly. Consequently, Shingo's application of Poka-Yoke throughout the Toyota production system enables Toyota to reduce muda thereby increasing operational efficiency.

5.5 Cross Trained Workers

As aforesaid, in the mass production system, workers usually performed one or two tasks repeatedly under the guidance of a foreman who does not perform any assembly tasks. Other tasks such as house-keeping, minor tool repair, and quality

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

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

checking are done by separate employees. At Toyota, Ohno grouped assembly workers into teams with a team leader who performed assembly tasks in addition to coordinating the team.[94] 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 lower cost within the Toyota Production System.

5.6 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.[95] 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

[94] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 56.

[95] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

production schedules.[96] 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 and therefore the inventory is eliminated. [97] 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 make Toyota more flexibility with their production decisions and afford the company cost reductions throughout the entire supply chain.

Kanban

Kanban, a Japanese term for "visual record", drives much of the manufacturing organization. It was originally developed at Toyota in the 1950s as a way of managing material flow on the assembly line. The Kanban process has developed into an optimum manufacturing environment leading to global competitiveness.[98]

Just-in-time is implemented at Toyota through the use of Kanban cards. Toyota uses Kanban cards to control the flow of material through their production system. There are tow types of Kanban cards. The first type of Kanban card is the production ordering Kanban (POK), which signals an upstream cell or process to produce a certain number of

---

[96] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

[97] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

[98] Kanban Integrated Systems, 11 Apr. 2005 <http://www.msc-inc.net/Documents/Kanban_Integrated_JIT_System.htm>.

parts. The second type of Kanban card is the withdrawal Kanban (WLK), which serves to link two cells or processes. Both POKs and WLKs are placed on standard carts, and the information on the cards show how many parts are in the cart. Figure 5 and 6 are examples of POK and WLK respectively:

Figure 5: Example of Production Ordering Kanban from the Automobile Industry

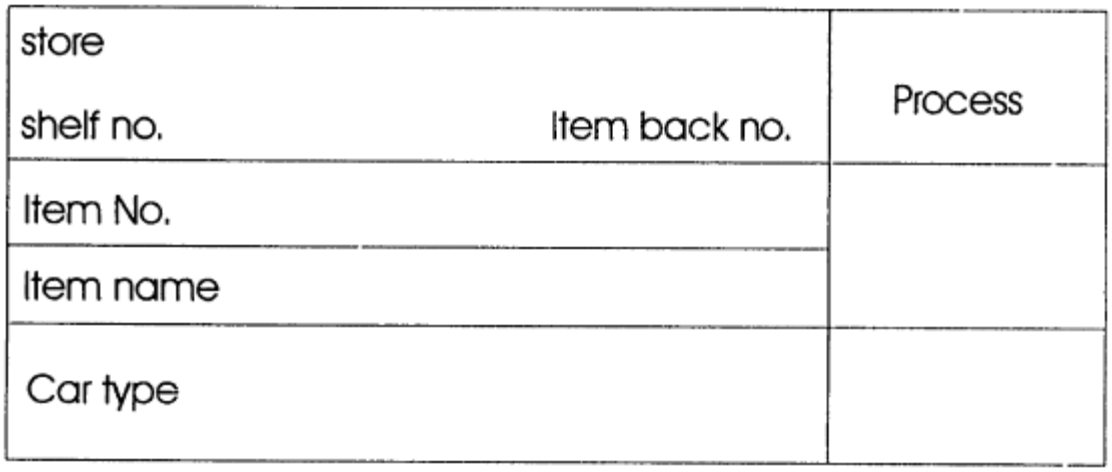
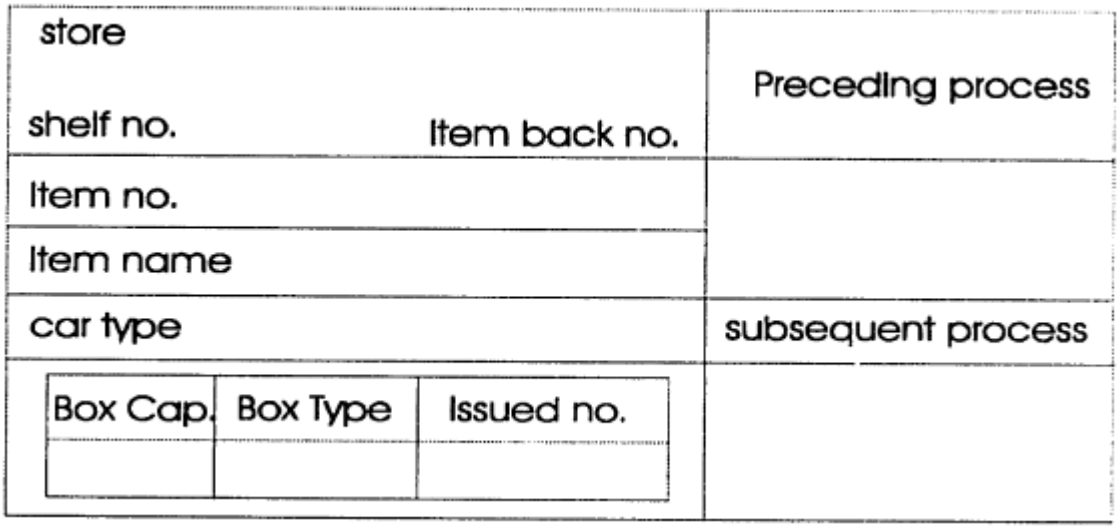


Figure 6: Example of Withdrawal Kanban from the Automobile Industry.



Six rules for Kanban use:

1. The downstream process should withdraw the needed products from the upstream cell or process according to the information provided on the WLK.
2. The upstream process should produce products in quantities withdrawn by the downstream process or cell, according to the information provided by the POK
3. Defective products should never be conveyed to the downstream process. If there is a defect, the line or cell should stop and immediately try to determine what corrective action should be taken
4. The number of Kanban cards can be gradually reduced in order to improve the process and reduce waste.

$$K = (D * L + S) / a$$

K = number of WLKs or POKs

D = expected demand per unit time

L = lead time

a = container capacity

S = safety factor

5. If there is no Kanban card, there will be no manufacturing and no transfer of parts.

6. Kanbans should be used to adjust to only small fluctuations in demand. (fine-tuning production by Kanban)

Rule number one controls the withdrawal of parts in the just-in-time system. Information on the WLK card dictates the amount to be withdrawn. A product is only withdraws when needed. The second rule determines the amount of product that is to be produced. In the just-in-time philosophy products are produced as they are needed. Rule number three brings quality control down to the line operators. As stated earlier, under the Toyota production system, defective parts should never be fed downstream. If a part is defective, corrective action should be taken before continuing production. Kanban cards are used for inventory control under rule four (see expression under rule four). Rule 5 simply states that if a Kanban card does not exist, there will be no manufacturing or transferring of parts. Flexibility is managed through the implementation of rule number 6.[99]

Lars-Uno Roos stated in his book *Resource Allocated Production* nine advantages in using kanbans:

> "1. A simple and understandable process
>
> 2. Provides quick and precise information
>
> 3. Low costs associated with the transfer of information

[99] Miguel Ochoa, "The Toyota Production System: a study of its components," diss., Massachusetts Institute of Technology, 1997.

4. Provides quick response to changes
5. Limit of over-capacity in processes
6. Avoids overproduction
7. Is minimizing waste
8. Control can be maintained
9. Delegates responsibility to line workers"[100]

The Kanban system at Toyota is used to implement pull-type controls in the production system, which reduces costs by minimizing work-in-process (WIP) inventory. This enables Toyota to adjust production more quickly in response to changes in demand. Under this system, first-tier suppliers only deliver components when they are needed, so that there is no storage of excess inventory. This contrasts with the traditional forecast method of inventory management, where parts are "pushed" to the production line based on anticipated (rather than actual) demand.[101]

Recently, alternatives to the Kanban system has emerged, called conwip and polca. Conwip, Constant Work In Process, is an adaptive production control method for setting WIP (Work In Process) levels to meet target production rates in a pull system.[102] Polca, Paired-cell Overlapping Loops of Cards with Authorization, is a materials control system used for QRM (Quick Response Manufacturing). [103] Companies across industries

[100] Roos, Lars-Uno. (1992) Resource Allocated Production. Almqvist&Wiksell, Malmo, Sweden.
[101] FactoryLogic: Leading Lean, 1 Apr. 2005 <http://www.factorylogic.com/nl_26.asp>.
[102] Setting WIP Levels with Statistical Throughput Control, 24 Apr. 2005 <http://users.iems.nwu.edu/~hopp/reprints/Setting%20WIP%20Levels%20with%20Statistical%20Throughput%20Control.pdf>.
[103] QRM and Polca, 24 Apr. 2005 <http://www.engr.wisc.edu/centers/cqrm/files/publications/qrm21st.pdf>.

seeking to implement the Kanban system responded to minor inefficiencies (usually industry specific) with these two new systems. Essentially, the new systems follow the basic 'pull' approach as the Kanban system.

5.7 Heijunka (Stable Production Schedules)

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 the model mix scheduled on a given line."[104] 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. This allows for consistent workflow with the eventual goal of being able to produce any product any day. The main benefits related to Heijunka are: reduced costs,

[104] FactoryLogic: Leading Lean, 1 Apr. 2005 <http://www.factorylogic.com/nl_26.asp>.

reduced lead time, maximize resource utilization, and reduced inventory.

Chapter 6. Toyota Supply Chain

In the traditional supply chain structure for the automotive industry, manufacturers vertically integrate suppliers. Often, suppliers bid against one another to produce a particular system (first tier suppliers), or part (second tier suppliers). The supplier with the lowest bid received the production order. Since suppliers were in a bidding competition against one another, they would not share information on advances in manufacturing techniques. Moreover, manufacturers were uncertain if suppliers could reduce cost of production through new techniques.[105] Coordinating the flow of parts throughout the supply chain on a day to day basis posed challenges. Due to the erratic nature of orders, first and second tier supplier would often hold large stocks of inventory in warehouses so that the assembler would never have the cause to complain or cancel a contract because of a delay in delivery.[106]

[105] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 58.
[106] Ibid., 59.

Toyota's supply chain is organized into functional tiers. The following figure (Figure 7) illustrates Toyota's just-in-time supply chain:

Figure 7: Toyota's Just in Time Supply Chain

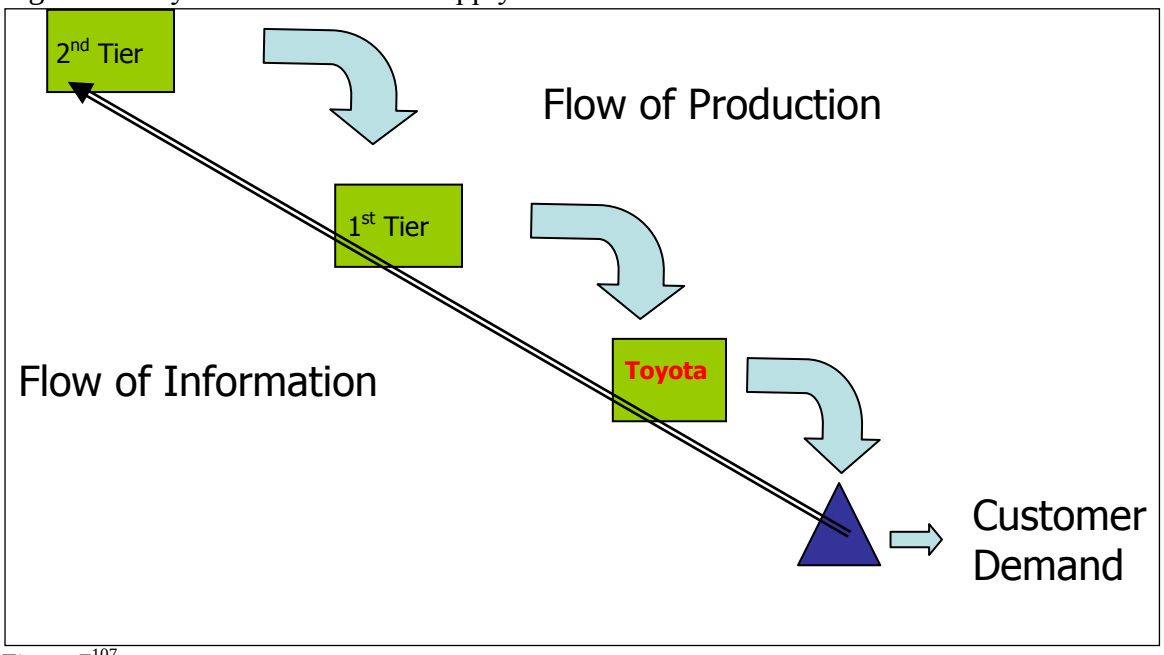


Figure 7[107]

6.1. 1st Tier Suppliers

First tier suppliers are responsible for working as an integral part of the product development team in developing a new product.[108] Typically, Toyota will request that suppliers develop a prototype for steering, braking, or an electrical system. This request would be accompanied by a performance specification. For example, Toyota makes a request to various suppliers for a braking system. The performance specification would require that the brakes stop a 2000lb car at a certain distance, ten consecutives times,

[107] Genaro J. Gutiérrez, McCombs School of Bus. The Univ. of TX at Austin, 15 Feb. 2005 <www.sachamber.org/councils/ ecodev/toyota/ToyotaProductionSystem.ppt>.
[108] Daniel T. Jones, Daniel Roos, and James P. Womack, The Machine That Changed The World (New York: Harper Perennial, 1991) 59.

without fading.[109] Also, the suppliers are given information on other systems within that model, the size (dimensions) of the prototype, and the cost that Toyota is willing to pay per set. If the prototype worked, that particular supplier got the production order. Toyota does not specify what the brakes have to be made of or how they are to work. Toyota leaves these decisions for the supplier's engineers to make. Lastly, Toyota encourages its first tier suppliers to talk amongst each other in order to allow the flow of information horizontally across first tier suppliers.[110] As a result of information sharing, suppliers are able to decrease the cost of production through improved organization and process innovation. This eliminates waste at the first tier supplier level.

6.2. Second Tier Suppliers

Each first tier supplier form a second tier of suppliers under itself. Companies in the second tier were assigned the job of fabricating individual parts. These suppliers were manufacturing specialists, usually without much expertise in product engineering but with strong backgrounds in process engineering and plant operations. For instance, if a first tier supplier was responsible for manufacturing alternators, they would obtain the 100 plus parts that make up an alternator from a group of second tier suppliers.[111] First tier suppliers group their second tier suppliers into supplier associations so that they too could exchange information on advances in manufacturing techniques.

[109] Ibid., 60.
[110] Ibid., 62.
[111] Ibid., 60.

6.3. Supplier Relations

Toyota extends its relationship with its suppliers in many ways in order to add value to the entire supply chain. Toyota owns equity in the majority of its suppliers.[112] Further, Toyota's suppliers have substantial cross-holdings in each other creating a win-win relationship throughout the supply chain. Secondly, Toyota "often acts as a banker for its supplier groups, providing loans to finance the process machinery required for a new product.[113] Lastly, Toyota shares personnel with its supplier firms. Toyota lends suppliers personnel to deal with workload surges, and it transfer senior managers not in line for top positions at Toyota to senior positions in supplier firms.[114]

6.4. Adoption of TPS throughout the 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 are (when to produce and how much to produce, when to order and how much to order)

[112] Ibid., 61.
[113] Ibid., 61.
[114] Ibid., 61.

pulled through the entire supply chain eliminating coordination issues. Toyota pressures suppliers to share information (vertically and horizontally) so that muda 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.

Bibliography

Alliance of Automanufacturers. 12 Mar. 2005 <http://www.pittsburghmultimedia.com/auto>.

Answers. 1 Mar. 2005 <http://www.answers.com/automotive%20industry>.

Becker, Ronald M. (2005), "Lean Manufacturing and the Toyota Production System," <http://www.sae.org/topics/leanjun01.htm.>

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

Economist. 27 Jan. 2005. 2 Apr. 2005 <http://www.economist.com/business/displayStory.cfm?story_id=3599000>.

FactoryLogic: Leading Lean. 1 Apr. 2005 <http://www.factorylogic.com/nl_26.asp>.

Gutiérrez, Genaro J. McCombs School of Bus. The Univ. of TX at Austin. 15 Feb. 2005 <www.sachamber.org/councils/ ecodev/toyota/ToyotaProductionSystem.ppt>.

Hoovers. 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10640>.

Hoovers. 12 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=41867>.

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

Hoovers. 13 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=110300>.

Hoovers. 3 Feb. 2005 <http://premium.hoovers.com.libproxy.mit.edu/subscribe/co/factsheet.xhtml?ID=10597>.

Isidore, Cris. CNN. 10 Jan. 2005. 4 Mar. 2005 <http://money.cnn.com/2005/01/09/pf/autos/autoshow_walkup/>.

Jones, Daniel T., Daniel Roos, and James P. Womack. The Machine That Changed The World. New York: Harper Perennial, 1991. 149-150.

Kanban Integrated Systems. 11 Apr. 2005 <http://www.msc-inc.net/Documents/Kanban_Integrated_JIT_System.htm>.

Morell PhD, Jonathon; Phelps PhD, Thomas A. A Review of Interoperability Issues In the Automotive Industry 15 Feb. 2005 < http://www.jamorell.com/Jonny/web_new/nacfam-7_a.pdf>.

Ochoa, Miguel. "The Toyota Production System: a study of its components." Diss. Massachusetts Institute of Technology, 1997.

Ohno, Taiichi. Toyota Production System. Portland, Oregon: Productivity P, 1978. 17.

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

Pricewaterhouse Cooper. 21 Feb. 2005 <http://www.pwcglobal.com/Extweb/pwcpublications.nsf/docid/4EFBA3D2E36509CC85256BDE006BEC7B>.

Quality Coach: Shigeo Shingo. 13 Mar. 2005 <http://www.qualitycoach.net/shingo.htm>.

Roos, Lars-Uno. (1992) Resource Allocated Production. Almqvist&Wiksell, Malmo, Sweden.

Spitzer, Richard D. Accenture. 4 Mar. 2005 <http://www.accenture.com/xdoc/en/industries/products/automotive/track/hiperf_auto.pdf>.

Standard and Poors Industry Survey Autos & Auto parts. 15 Mar. 2005 <http://www.standardandpoors.com>.

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

Toyota Annual Report. 2 Feb. 2005 <http://www.toyota.co.jp/en/ir/reports/annual_00_03.html>.

TWI: Kaizen. 12 Apr. 2005 <www.tdo.org/twi/TWI.ppt>.

Wards. 14 Feb. 2005 <http://www.wardsauto.com>.