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How to decode the DNA of the strategy of Toyota Production System? The case of Toyota Material Handling

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ABSTRACT

There is an increasing attention to improving the sustainable performance of the firms. This study aims to understand how to build an effective strategy for lean management. Field research is conducted with quantitative and qualitative methodology. The results describe some distinguishing features of TPS (Toyota Production System). The study gives a new practical framework for the development of a strategy to innovate and improve the processes.

L'attenzione al miglioramento delle performance sostenibile delle imprese è in aumento. Questo studio si propone di comprendere come costruire una strategia efficace per la gestione snella (*lean management)*. È stata condotta una ricerca sul campo con una metodologia sai quantitativa che qualitativa. I risultati descrivono alcune caratteristiche distintive di TPS (Toyota Production System). Lo studio fornisce un nuovo framework pratico per lo sviluppo di una strategia per innovare e migliorare i processi.

Keywords: Lean management, strategy, Toyota Production System, sustainability, vision

1 – Introduction

The concept of lean management (Ohno, 1988; Womack and Jones, 1996) can be traced back to the practices of Venice's Arsenal, but Taiichi Ohno is credited with developing a systematic theory of applying it (Black, 2007; Chiarini, 2014; Deming, 2000; Goldrat, 1992; Graziadei, 2006, Hammer *et al*., 1993; Imai, 1986, Itami and Roehl, 1993). Ohno was an industrial engineer and businessman who worked at Toyota Motor Company. He is the father of the Toyota Production System (TPS), which is a set of

principles and practices that aim to eliminate waste and inefficiency in manufacturing; it is based on the Kanban System (see Figure 1).

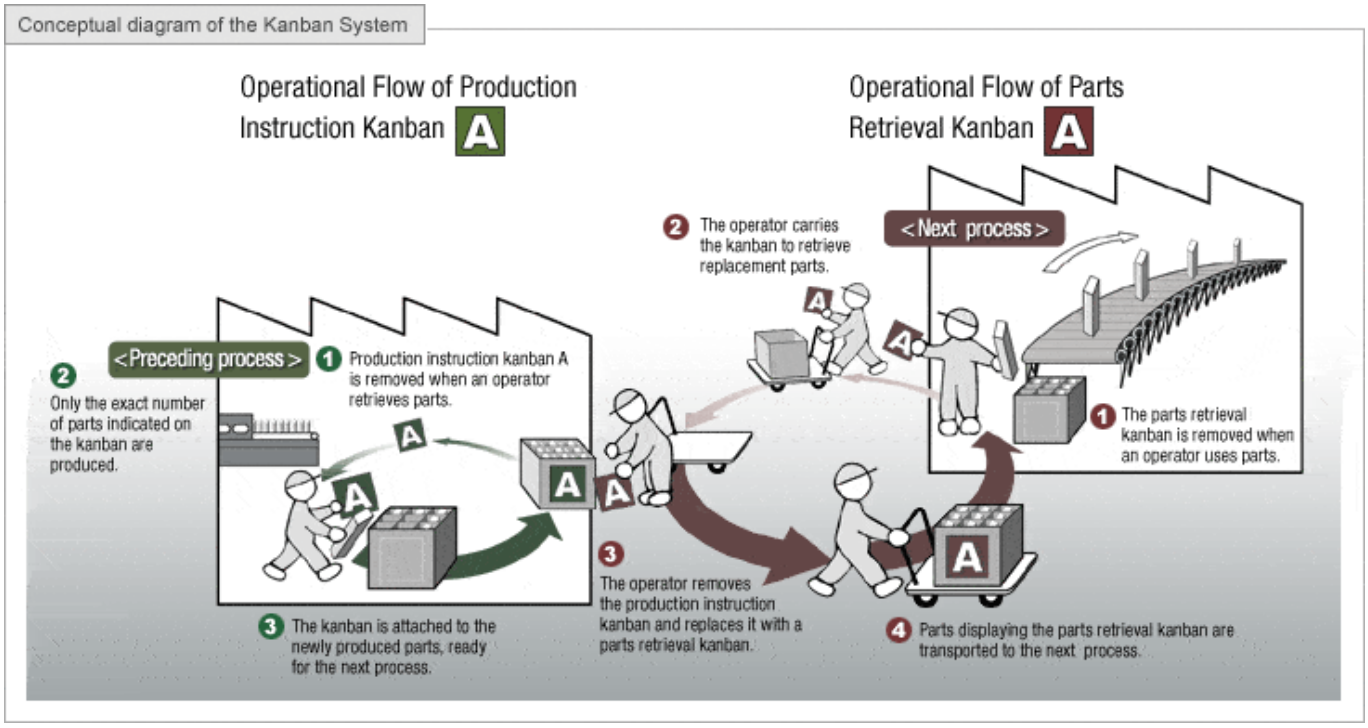

Fig. 1 – The Toyota production system and Kanban (source elaboration from Kambazone)

The Toyota Motor Corporation (Collis, 2016; Senge, 1990; Riva and Pilotti, 2019a, 2021a; Mella, 2021a, b) was founded in August 1937 by Toyoda Automatic Loom Works, one of the largest textile industries in the world. Ohno moved to Toyota Motor Company in 1943, where he worked as a shopfloor supervisor in the engine manufacturing shop of the plant. There are some definitions of lean management (Table 1).

Ohno wrote several books about the TPS, including *Toyota Production System: Beyond Large-Scale Production*. The seven wastes identified by Ohno are still used today as a framework for identifying and eliminating waste in manufacturing processes.

Lean production has been shown to be a very effective way to improve efficiency and productivity. It has been used by companies in a wide variety of industries, including manufacturing, healthcare, and retail.

Ohno identified seven types of waste, or "muda," that can occur in manufacturing processes. These wastes include overproduction, waiting, transportation, inventory, motion, defects, and underutilized talent. Ohno's work has had a profound impact on manufacturing around the world.

The literature appeals with some limits about some aspects of TPS (Toyota Production System) (Nonaka, 1995; Qintas *et al.*, 1997; Mella, 2012, 2015; Gazzola and Colombo, 2014; Gazzola *et al.*, 2020; Stack *et al.*, 1992; Riva and Pilotti, 2018b; Cortiglioni *et al.*, 2017). Consequently, this paper aims to analyze the following relevant research- questions:

RQ1: *How to Decode the DNA of the strategy of the Toyota Production System?*

RQ2: *How is it possible to develop a strategy and control system based on TPS (Toyota Production System)?*

Tab. 1 – Definition of lean management and TPS (Toyota production system) (source our elaboration)

AUTHOR	DEFINITION
Womack, Jones, Ross (1990)	**Lean production is a fusion of mass and craft production that aims to eliminate waste and inefficiency throughout an organization.** **It is a set of principles and best practices that focus on continuous improvement and delivering value to customers.**
Krafcik (1988)	**Lean production uses less organizational resources than mass production.**
Shah, Ward (2003)	**Lean is an integrated system consisting of inter-related elements and management practices aimed at delivering value to customers.**
Shah, Ward (2007)	**Lean is also a socio-technical system, which means that it takes into account the social and technical aspects of an organization.**
Liker (2004)	**The goal of lean production is to create a smooth, efficient flow of work that eliminates waste and delivers value to customers; this is achieved through a variety of principles, including:** a) **value stream** mapping: this is a process of identifying and mapping the flow of value through an organization. b) **kaizen**: a japanese word that means "continuous improvement." it is a philosophy of constantly looking for ways to improve processes and eliminate waste. c) **just-in-time** (jit): a system of production that delivers the right number of materials at the right time to the right place. d) **kanban**: a visual system for managing work and inventory.

After the introduction, the second section provides some theoretical background, and the third describes the methodology; the fourth section shows the case, the fifth section discusses the empirical findings and the last concludes.

2 – Theoretical background

2.1 – *Theoretical background*

There are important relevant studies (Liker 2004; Ohmae, 1982, 2012; Pisano, *et al*., 2014. Porter, 1980, 1992,1998, 2000; Spear *et al*., 1999; Stalk *et al*., 1992; Teece, 2010; Womak *et al*., 1990, 1994, 2003) on the field (see Table 2).

Tab. 2 – The relevant studies (source our elaboration)

	Authors	Theoretical perspective	Methodology	Main findings	Context	Sample
	I) Origin and Principles					
1	**Taylor (2011)**	***Principle of scientific management***	Analyze of organization line and processes	**Importance of time, order, productivity efficiency Law of "one best way"**	Automobile industry	Ford Company
2	**Onho (1988)**	***General analyse of TPS (toyota production system***	Description of Toyota production strategy	**The new logic of production importance of Just in time Jidoka e Kaizen**	Toyota Plan	Japan Toyota plan's
3	**Womack and Jones (1990)**	***Analyze of performance of toyota compared with other automobiles companies***	Description of the new logic of production of TPS (Toyota production system)	**Logic of lean management and just in time and standardization and simplification of processes**	Toyota method and performance	Toyota factory
4	**Deming (1982)**	***Importance of improvement***	General study	**13 Principle Focus on quality**	Japan Factory	Japan industry
5	**Senge (1990)**	***Systemic vision***	General Study	**5 Laws**	General	General
	II) Review					
6	**Sinha, Matharu, (2019).**	***General review of litterature***	Classification of area of study	**Importance of application of TPS (Toyota production system) and lean management**	General	N.A.
	III) Implementation study					
7	**Santos Bento** *et al*. **(2018)**	***Measure lean manufacturing***	Large case study	**Importance of self-evaluation of implementation for TPS**	Brazil	90 Manufactu-ring Company
8	**Spear** *et al*. **(1999)**	***Micro-analyze. analyze of how People work, connect, organization of production line, strategy to improve in toyota***	Analyze of production line and routine in Toyota's Plans and how people improve	**Defining rules and standards (timing, sequences, rigid specification of task but desire to innovate**	Toyota world plans	Toyota 's Plans

9	**Black (2007)**	***Design rule of toyota production system***	Definition of Rules in Toyota plans	**A set of principle and measure to implement TPS**	Toyota plans lean factory	Toyota Plans
10	**Holweg (2007)**	***Evolution of toyota production system***	Definition of FCS for the development of Toyota strategy	- **Important of decentralization and public policy promotion**	Toyota plan	Nord American Toyota Plans
11	**Womack** *et al*. **(1994)**	***The importance of process and motivastion of team***	The logic of lean enterprise	- **The importance of continuous improvement**	Toyota	Nord American and European company
12	**Macduffie (1995)**	***Focus on human resources***	Case study	- - **Definition of Main indicators**	Plans in different county (Japan, America, Europe)	90 plans
13	**Camuffo, Secchi (2021)**	***Lean strategy and knowledge***	Case study	- **General description of lean implementation**	Service Sector	Service Sector
12	**Cortiglioni et al. (2017)**	***Lean management***	Case Study	**The strategy of Toyota Way in contest of industry 4.0**	Toyota in Italy	Toyota single case study

This study explores the challenges and opportunities of lean management (Deming, 2000; Ohno, 1988; Shingo, 1981; Womack and Jones, 1996) in the context of Toyota Material Handling (TMH) (Holweg, 2007; Womack and Jones, 1990; Collis, 2016; Imai, 1986; Senge, 1990; Pilotti, 2005, 2011).

It discusses the challenges and opportunities that have been faced in implementing lean management, as well as the benefits that they have realized (Mella, 2012; Riva and Pilotti, 2018a, b; Pilotti, 2019; Riva, 2005, 2006, 2007, 2010; 2012; Kaplan and Norton, 1996, 2001, 2004a, 2004b).

Lean management is a manufacturing philosophy that emphasizes the elimination of waste and the continuous improvement of processes (Nonaka, 1995; Qintas *et al*., 1997; Mella, 2012, 2018, Gazzola and Colombo, 2014; Gazzola *et al*., 2020).

The key challenges of implementing lean management sector are:

a) the need to balance the demands of lean production with the need to customize motorbikes to meet the needs of individual customers;

b) the need to maintain a high level of quality while reducing costs;

c) the ability to improve efficiency and reduce costs. the ability to improve quality and customer satisfaction.

There are many contributions to productivity; historically Frederick Taylor (1856-1915) is considered the father of scientific management. In his important book "*The Principle of scientific management*" (Taylor, 2011) he describes his theory of management and organization of the firm.

The task of management is to discover these laws of the "*one best way*" to do things. Taylor stresses the importance of time, order, productivity, and efficiency.

A relevant and important contribution is scientific management where the production is based on universal law. He invented the time-motion study and stress the importance of eliminating waste. The production of car Model T by Ford in 1908 (priced at $950) was influenced by the theory of "*one best way*". Important is the role played by the evaluation: the team is an independent executive institution, which carries out investigations, analyses, and assessments intended to provide an understanding of the trends and results. Edwards Deming (1900-1993) is considered the father of quality control (quality, low costs, high productivity, low price). The concept of continuous improvement implies an ongoing process of questions on the processes. In his book (Deming, 2000) "Out of the Crisis" he describes the importance of long-term commitment to new learning and a new philosophy for managers.

The research on lean management is organized in many specific areas (see Table 3).

Tab. 3 – The main study on lean management is divided into the specific area of study (source elaboration from Sinha *et al*., 2019).

AREA	AUTHORS	FOCUS
Lean adoption	Nordin, Deros & Wahab, 2011; Bhasin, 2012; Sisson & Elshennawy, 2015. Abolhassani, Layfield & Gopalakrishnanz, 2016; Tortorella, Marodin, Fettermann & Fogliatto, 2016. Narayanamurthy, Gurumurthy & Chockalingam, 2017; Satolo, Hiraga, Goes & Lourenzani, 2017.	***Includes factors impacting lean implementation; barriers or issues faced while adopting lean; lean product development etc.; implementation and application in various industries such as healthcare, education etc.***
Lean performance	Bhasin, 2008; Fullerton & Wempe, 2009; Belekoukias, Garza-Reyes & Kumar, 2014; Uhrin, Bruque-Camara & Moyano-Fuentes, 2017; Negrão *et al*., 2017.	***Includes impact of lean on organizational performance including operational performance, financial performance etc.***
Leanness	Papadopoulou & Özbayrak, 2005; Singh, Garg & Sharma, 2010; Vinodh & Kumar-Chintha, 2011; Ram-Matawale, Datta & Sankar-Mahapatra, 2014.	***Includes research papers that discuss leanness assessment or measurement.***

Lean supply chain	Stentoft-Arlbjørn, Vagn-Freytag & de Haas, 2011; Ma, Wang & Xu, 2011; Jasti & Kodali, 2015a; Tortorella, Miorando & Tlapa, 2017.	***Includes papers that discuss adoption of lean principles, concepts, tools and techniques throughout the entire supply chain aimed at elimination of waste and non-value-added activities from the overall value stream in the supply chain***
Lean and other value creation tools	Dahlgaard & Dahlgaard Park, 2006; Naslund, 2008; De Koeijer, Paauwe & -Huijsman, 2014; Mehrsai, Thoben & Scholz-Reiter, 2014.	***Includes papers which discuss lean and other process improvement methodologies like TQM, Six sigma, Agile.***
Lean epistemology	Bhasin & Burcher, 2006; Found & Rich, 2007; Petterson, 2009; Saurin, Rooke & Koskela, 2013; Langstrand & Drotz, 2016.	***Includes research articles that deliberate on its conceptual issues, methods, validity and scope.***
Organizational theory and lean	Forrester, 1995; Conti, Angelis, Cooper, Faragher & Gill, 2006; Bamber *et al*., 2014; Pakdil & Leonard, 2015; Worley & Doolen, 2015; Tortorella, Marodin, Fogliatto & Miorando, 2015.	***Includes papers examining relationship between Human resource management, Culture,*** ***Management support, leadership and lean***
Lean and sustainability	Alves & Alves, 2015; Longoni & Cagliano, 2015; Piercy & Rich, 2015; Hallam & Contreras, 2016; Raj, Ma, Gam & Banning, 2017.	***Includes research articles that discuss relationship between lean and sustainability and green practices***
Industry 4.0 and lean	Mrugalska & Wyrwicka, 2017; Kolberg, Knobloch & Zühlke, 2017; Tortorella & Fettermann, 2018.	***Impact of new technology of performance***

Deming stresses the importance for every organization to improve (*kaizen*). He is famous for the Deming cycle: *Plan, Do, Chec,k Action*.

The improvement is based on strategic planning. He published books covering motivation and human psychology, quality control, statistical variance, and systems thinking. He helped important firms to apply management methods.

Lean management can be used with other methodologies (see Table 4).

Sigma can be used in lean management strategy. There is the importance of integration of the two methodologies of Lean and Six Sigma. In Lean the focus is on value-added expenditure from the customer's point of view to eliminate the "Muda" (waste), instead in six sigma the attention is on the elimination of defects. For his effort, Motorola got in 1986 the Malcolm

Baldrige National Quality Award. Each Six Sigma project follows a definite sequence of operations with a specific value target: reduce process cycle time (TC) and cost, and increment customer satisfaction.

Tab. 4 – Lean management and other methodologies (source our elaboration)

	METHODOLOGY	MAIN AUTHORS
1	**Lean management**	Ohno,1986; Shingo, 1981; Womack and Jones, 1996; Liker, 2004; Camuffo *et al*., 2017
2	**Six sigma and lean sigma six**	Smith, 2003; Majorana and Morelli, 2011; George, 2003 Delgado *et al*., 2010; Folpmers *et al*., 2004; Kovacs, 2011; De Koning *et al*., 2008; De Antonio, 2008
3	**Quality management:**	Deming, 2000; Imai, 1986
4	**Benchmarking**	Camp, 2006; Zairi, 1996
5	**Reengineering and change management:**	Hammer and Champy, 1993
6	**Scientific management**	Taylor, 1911; Ford and Crowther, 1922; Drudy, 1915; James, 1912
7	**Process management:**	Weske, 2012
8	**Knowledge management**	Nonaka and Takeuchi, 1995; Itami, 1986
9	**Change management:**	Senge, 1990
10	**Theory of constraint:**	Goldratt, 1992
11	**Risk management**	Smullen, 2000
12	**Balance scorecards and kpi**	Kaplan and Norton, 1996, 2001
13	**System dynamics**	Senge, 1990

The Theory of Constraints (Goldratt, 1992) can be integrated with lean management (see Table 5) and is a very useful tool for analyzing constraints in the value stream and speeding the process to discover what are the elements that stop the process to reach the goal. The enterprise as a system oriented to a specific goal is one of the cornerstones of the theory of constraints (TOC). It is a set of processes and flows oriented to the creation of value. Six Sigma is based on the reduction of defects, on the contrary lean management is based on the elimination of waste. The two main methodologies are DMAIC used to improve the existing process and DMAIV or DFFSS to create new processes and products.

Tab. 5 – Lean management and theory of constraints (source: adapted from Goldratt 1984 and Slack *et al*. 2016)

	LEAN MANAGEMENT	CONTRAINTS'S THEORY
Objectives	To increase profit by adding value from the costumer perspective	To increase profit by increasing the throughput of process or operation
Measure	Cost Throughput time value added efficiency	Throughput Inventory Operating costs
Strategy To improve	Eliminating waste ad adding value by considering the entire process Operation or supply Network	Focusing on the constraints the 'weakest link' in the process
Method	Continuous improvement emphasizing the whole supply network	A five- step, continuous process emphasizing acting locally

It is important to transform employers into problem solvers always looking for new improvements. It is useful that each in person in company performs two tasks: work following the instructions and at the same time seek ways to improve the way to do that job.

The quality strategy (Camuffo *et al*., 1997; Chase *et al*., 1992; Cortilioni *et al*., 2017; De Carlo *et al*., 2018; Djekic *et al*., 2014; Eisenhardt, 1989; Fliedner, 2008; Gazzola, *et al*., 2014,2000; Gazzola and Mella 2003, 2006, 2017; Glaser *et al*., 1967) affects everyone in the company and takes priority.

To pursue excellence requires that all staff use the most efficient methodologies to promote the quality that generates profit based on 5S (see Figure 2).

Quality is focused on the wider issues of planning and organization, managerial responsibility for quality, and the importance of setting targets for improvement. For the quality policy, an effective tool is the quality strategy. It can be composed of a:

a) orientation declaration to the quality;

b) appointment of the management representative;

c) purpose and scope of the standard;

d) organizational chart; e) list of procedures.

The continuous improvement of all business activity is based on the idea that man has the resources to implement continuous improvement.

Company's strategy requires a long-term vision (for a 5 - 10 years period) to develop a strategy for ongoing improvement and achieve their goals (increase the throughput and decrease the inventory and the cost).

Fig. 2 – The 5's of the Toyota production system
(source elaboration from Cortiglioni *et al*. 2017; and Kambanzone)

3 – Methodology

3.1 – *The motivation of choice of the case of Toyota Material Handing*

We select Toyota Material Handing (Cortiglioni *et al*., 2017) because is a case of excellence. It is a part of the group Toyota Motor Corporation (TMC) which is the world's largest automaker by production and the ninth-largest company in the world by market capitalization; it is a Japanese multinational automotive manufacturer headquartered in Toyota City, Aichi, Japan.

3.2 – *The primary data*

For primary data, we collect data (Eisenhardt and Martin 2000) and information by questionnaire and interviewees with experts. We analyze the many secondary data (see Table 6).

Tab. 6 – Secondary data used in this research (Source: our elaboration**)**

MAIN SECONDARY DATA	FOCUS
Toyota Material Handling annual report Europe (2021, 2022)	Focus economy and financial situation
Toyota industry report (2021,2022)	Global toyota report
"Rapporto sostenibiltà Toyota Material Handling" (2021)	Focus global
"Codice etico. Codice di condotta Toyota Material Handling" (2021)	Focus ethic aspect
Toyota sustainability report (2022)	Global sustainability strategy
Toyota integrated report (2022)	Communicate toyota policies

3.3 – *The quantitative analyze*

The questionnaire is organized into several sections based on a 5-point Likert scale. We have chosen an elaboration of the questionary to measure the implementation of lean management practice (Table 7).

Tab. 7 – Questionnaire (5 points Likert scale)

DIMENSION	Unaccepta-ble (1)	Almost Acceptable (2)	Acceptable (3)	Good (4)	Excellent (5)
Q1. Use of value stream mapping					
Q2. Use of standardization					
Q3. Adoption of a kaizen					
Q4. Use of production cells					
Q5. Supply long-term relation					
Q6. Plan to reduce set up time					
Q7. Kanban system					

Q8. Use of one-piece flow					
Q9. Reduction of lot sizes					
Q10. Reduction of buffer inventories					
Q3. Management style participative					
Q11. Problem solving method					
Q12. Use of 5s					
Q13. Visual mode of organization					
Q14. Trained in lean principles					
Q15. Classified as direct or indirect cost					
Q16. Compare actual results to budget					
Q17. Lean thinking in all					
Q18. Focus on cycle-time improvement					

3.4 – *The interview protocol*

The interview protocol (see Table 8) is used to focus on specific areas of the research questions. It also included a triangulation method to compare the data.

Tab. 8 – Interview protocol and main topics covered during the collection of data (Source: our elaboration)

MAIN QUESTION	SUB-QUESTION
RQ1: ***How to Decode the DNA of the strategy of the Toyota Production System?***	(1) Which are the main principles? (2) Why? (3) What are the reasons for the performance? (4) Why are the main limitations? (5) What will happen in the future?
RQ2: ***How is it possible to develop a strategy and control system based on TPS (Toyota Production System)?***	(1) What are the priorities? (2) What are the achieved benefits? (3) How is evaluated? (4) How are strategy and process improvement used? (5) How other strategies are applied? Why?

Semi-structured interviews are organized to analyze the main questions. The interviews are conducted by telephone or in-person and lasted for about 40-60 minutes. All participants are experts (see Table 9).

Tab. 9 – Number of interviewees for the professional category (source: our elaboration)

Specialization of experts	Number of interviewees
Advisor	**4**
Professional consulting	**5**
Economic journalist	**1**

3.5 – *Control the validity and reliability of the study*

To ensure the validity and reliability of these studies, we analyzed them using three methods:

ì) Construct validity: collecting data from multiple sources to ensure that the studies were measuring what they were intended to measure.

ii) Internal and external validity: we used an interview protocol to ensure that the studies were conducted in a consistent and reliable manner and that the results could be generalized to other populations.

iii) Reliability: using a database to collect data to ensure that the results were consistent and repeatable.

4 - The strategy of Toyota Material Handling (TMH)

4.1 – *The History and Dimension*

Toyota Material Handling (Cortiglioni *et al*. 2017) is a global manufacturer of forklift trucks and other material-handling equipment. It is a subsidiary of Toyota Industries Corporation, which is one of the leading industrial machinery companies in Japan. Its products are sold in over 190 countries and regions. It offers a wide range of products and services, including service, maintenance, and training (see Figure 3).

Toyota Industry Corporation was founded in 1937 by Kiichiro Toyoda, the son of Sakichi Toyoda, who founded Toyoda Automatic Loom Works in 1926. The company's first car, the Toyoda AA, was produced in 1936. Its early products were mainly trucks and buses, but it began producing passenger cars in the 1950s.

Toyota Material Handling is important for international dimensions (see Table 10). It has been a leader in the development of new automotive technologies, including the hybrid electric

vehicle (HEV). The company has set a goal of reducing its greenhouse gas emissions by 50% by 2050. TMC is also working to develop more sustainable materials and manufacturing processes.

Fig. 3 –The line of production Toyota Material Handling (source: Toyota - Corriere)

Toyota Motor Corporation is a global leader in the automotive industry. The company is committed to innovation, sustainability, and quality. TMC's products are sold in over 170 countries around the world, and the company is a major player in the global economy. In August 1983 Toyoda organizes a meeting reserved for members of the enterprise for which begs the following question: "we are able to create a luxury car that is capable of challenging the best in the market?". By the positive response to this question, the Lexus was born that must overcome rivals like BMW and Mercedes.

Tab. 10 – Toyota Material Handling (Source: our elaboration from Toyota)

DIMENSION	DATA
Active	In 42 countries
Factories	5

Unit sold	177500
Truck on service agreement	438000
Sales and service company	21
Suppliers	+300
Trained service technicians	3437
Service visit for years	4,4 milions
GLOBAL TOYOTA INDUSTRIES CORPORATION	
EMPLOYEES	375235
STRUCTURE	3 BUSINESS SEGMENT: MATERIAL HANDLING, AUTOMOTIVE TEXTILE MACHINERY
TOYOTA MATERAIL HANDLING GROUP CORPORATION	
EMPLOYEES	46980
TURNOVER	11,6 BN EU
STRUCTURE	5 REGIONS: JAPAN, EUROPE, NORTH AMERICA, CHINA, INTERNATIONAL
TOYOTA MATERAIL HANDLING GROUP CORPORATION EUROPE	
EMPLOYEES	11608
TURNOVER	2.4 BN EU
STRUCTURE	30 OPERATION ENTITIES
Headquarters	Sweden
Central Marketing office	Brussels
Operational factory	5 in France, Italy and Sweden

The products of Toyota Material Handling (see Figure 4) are known for their quality, durability, and performance.

It is also a leader in innovation and continues to develop new products and technologies to improve material handling.

Fig. 4 – The main productions of Toyota Material handling
(source: Toyota Material Handling)

It's committed to providing its customers with the best possible products and services (see Figure 5). It is also committed to sustainable materials and processes in the manufacturing of its products.

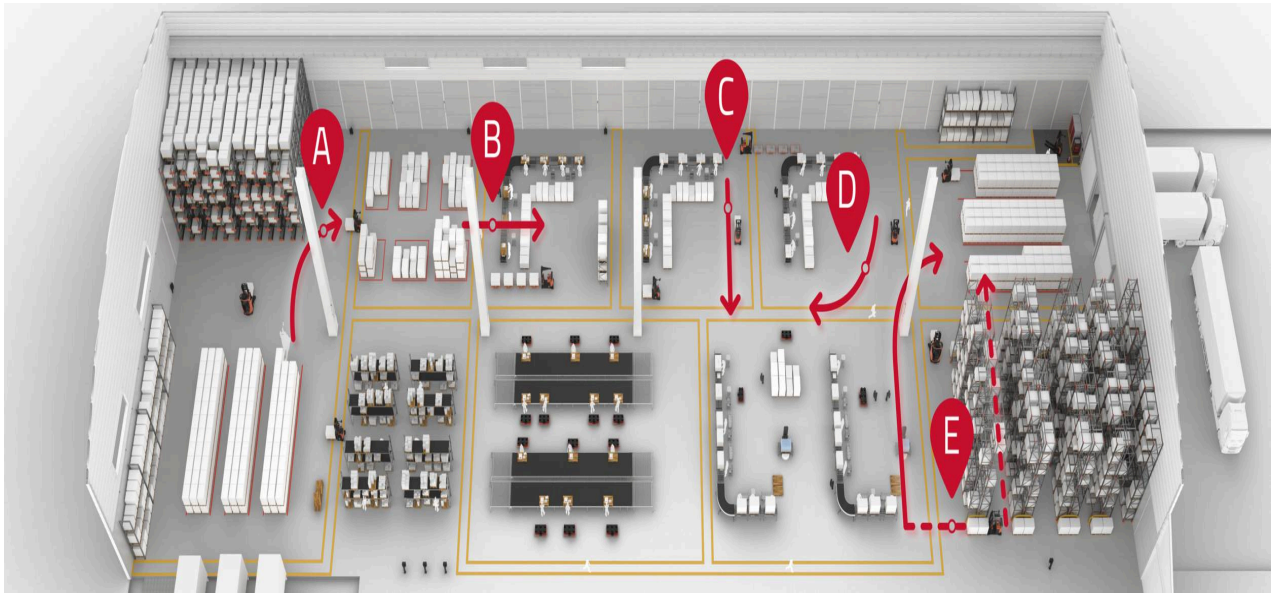

Fig. 5 –The system of organization and delivery of Toyota Material Handling
(source Toyota material handling)

Operational factories of THM are 5 in France, Italy, and Sweden. In Italy is present in Casalecchio di Reno vicino Bologna (see Figure 6).

Fig. 6 – The factory of Toyota Material handling (source: Fiom)

These strategies have helped Toyota to become one of the most successful companies in the world. The company is a leader in the automotive industry, and it is well-positioned for future growth. In general, Toyota tends to improve the quality of its products during this time (see Figure 7).

Here are some of the specific strategies that Toyota is pursuing:

I. Investing in new technologies: The company believes that these technologies will be essential for the future of the automotive industry.

II. Expanding into new markets: Toyota is expanding into new markets, such as China and India. The company believes that these markets have significant growth potential.

III. Developing new products and services: Toyota is developing new products and services. The company believes that these products and services will meet the needs of future customers.

The global strategy is Totora Material Handling is based on the control of continuous innovation based on the application of researching the elimination of the wastes in the processes during the time.

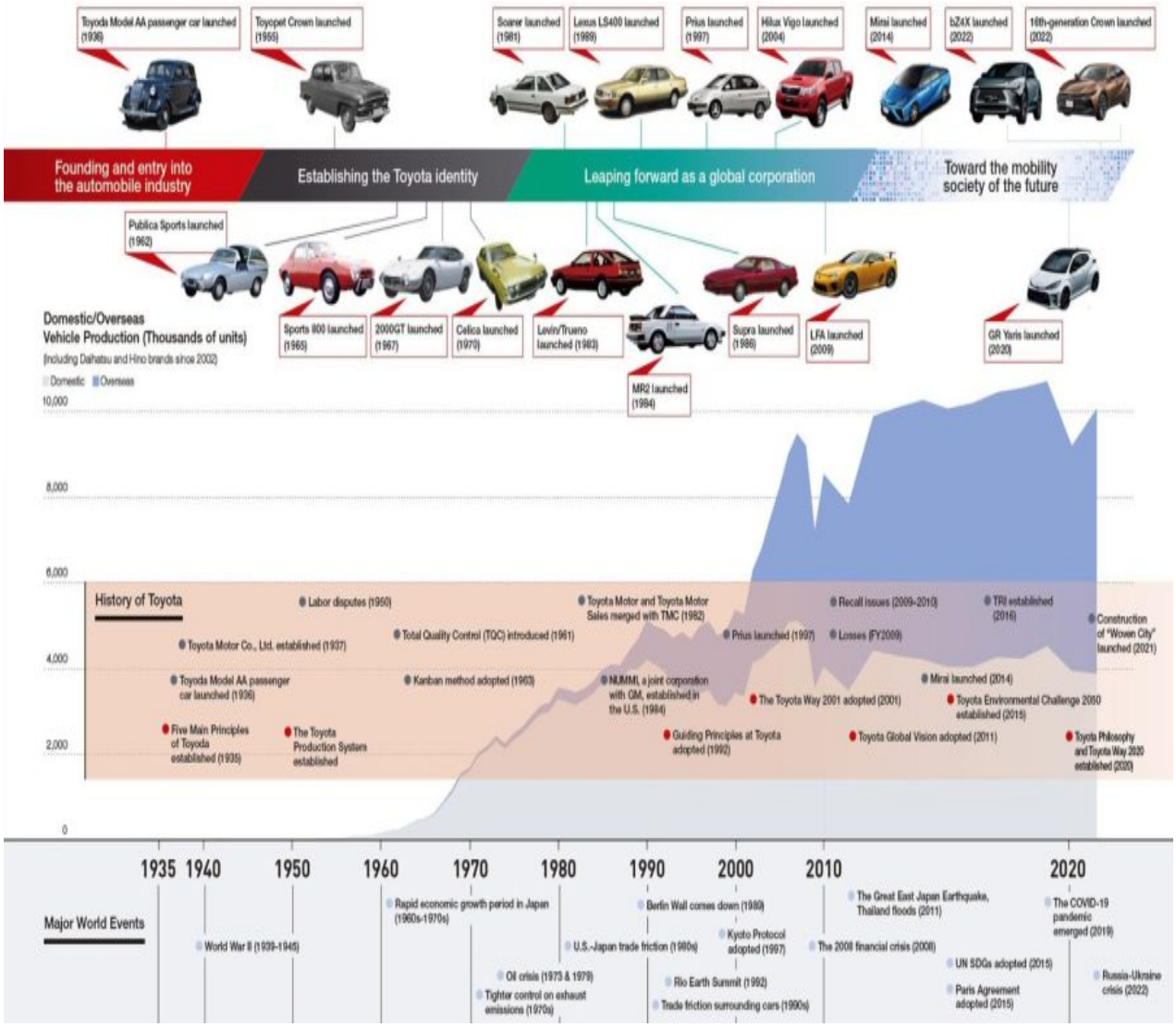

Fig. 7 – The evolution of innovation and production in Toyota (source Toyota)

5 – Discussion and managerial implication

5.1 – *The principles of TMH*

Toyota Material Handling uses the Toyota Production System (TPS); it has its roots in the work of Sakichi Toyoda, the founder of Toyota, who developed the concept of *Jidoka* in the 1920s. It means "automation with a human touch" and it is the idea that machines should be able to stop themselves if they produce defective parts (Ohno, 1988, Riva. 2006, 2007a, 2007b; Riva and Pilotti, 2020,2021a, b; Mella, 2021b). The method of Kanban is used in Toyota factories to improve performance (Cortiglioni *et al*., 2017) (see Figure, 8).

In the 1930s, Sakichi's son, Kiichiro Toyoda, invented the concept of JIT, which stands for "*Just-in-Time*". JIT is a manufacturing philosophy that emphasizes the elimination of waste and the delivery of parts and materials as they are needed in the production process.

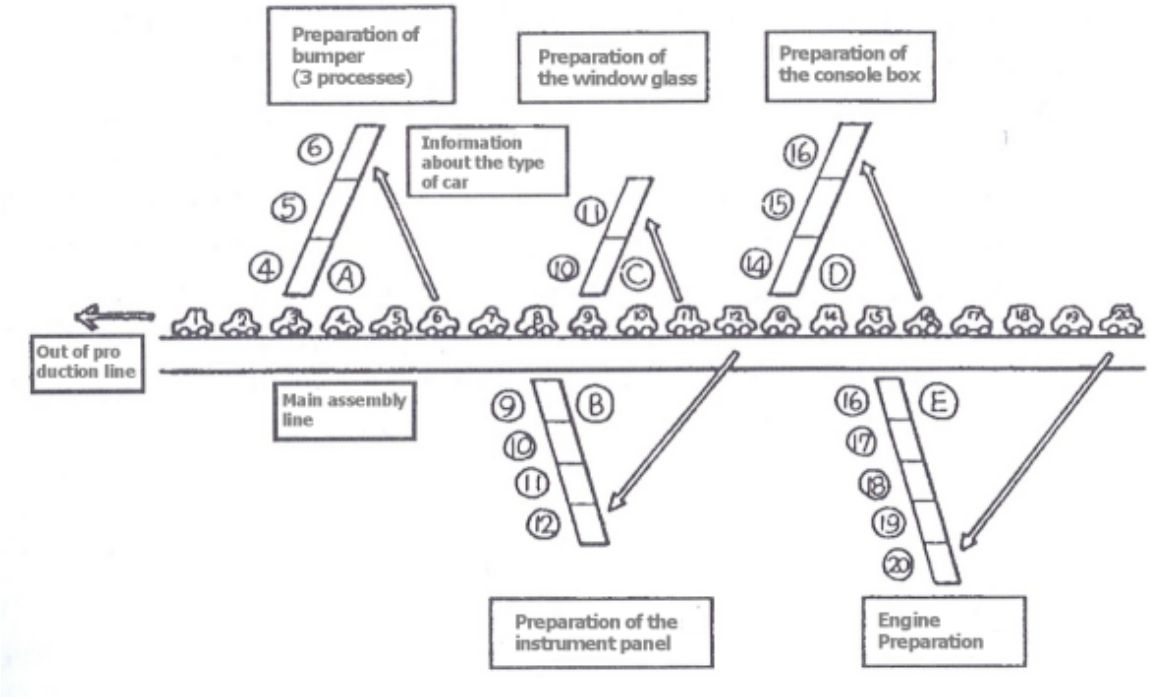

Fig. 8 – Line production and Kanban method (source: elaboration from Ohno 1997)

Lean management in Toyota Material Handling (see Table 11) is based on a set of principles and practices that aim to improve efficiency and waste reduction in organizations. There are many different strategies that can be used to implement lean management.

Tab. 11 – Global strategy in Toyota Material Handling (TMH) (source: our elaboration)

AREA	STRATEGY
Identifying and Eliminating Waste:	One of the core principles of lean management is to identify and eliminate waste. This can be done by mapping the value stream, which is a visual representation of the steps involved in creating a product or service. Once the value stream is mapped, it is possible to identify areas where waste is occurring. Waste can take many forms, including unnecessary steps, defects, and waiting time.
Creating Flow:	Once waste has been identified, it is important to create flow in the value stream. This means ensuring that materials and information flow smoothly through the process without interruption. Flow can be created by reducing batch sizes, balancing the workload, and eliminating bottlenecks.
Pulling Work:	Another key principle of lean management is to pull work, rather than pushing it. This means only producing products or services when there is a demand for

	them. Pulling work can help to reduce inventory levels and improve customer satisfaction
Continuous Improvement:	Lean management is a continuous improvement process. This means that organizations should always be looking for ways to improve their processes and eliminate waste. There are many different tools and techniques that can be used for continuous improvement, such as kaizen, six sigma, and value stream mapping.

We collect data about Toyota's profile (see Table 7); the results permit us to understand some strengths and weaknesses (see Figure 9).

Fig. 9 – The result of quantitative analysis (source: our elaboration)

In TMH the enterprise must be regarded as a flow (stability and standardization), and not as a series of processes or a series of separate products.

The concept of value stream which includes suppliers and customers is the foundation of the company and the new way to look at the production system that exceeds the vision only to processes and functions (see Table 12).

The production model of Toyota was the subject of imitation by many companies around the world; it is based on the quality and reliability of the product. The company philosophy is

built around the vision that: "*In the world, the man and the car must be able to live together in harmony*." (Liker, 1994).

Tab. 12 – Mission and values in Toyota Material Handling (our elaboration from Toyota Material Handling)

DIMENSION	ACTIONS
MISSION	1) To be the number one supplier for all those customers who are looking for material handling solutions, and to be widely appreciated not only for our innovative products and services but also for our respect for society. 2) To create a climate of trust and confidence with our customers by offering high-quality products and services that can add value to their businesses. 3) To meet the expectations and ambitions of our employees, suppliers, and shareholders by constantly striving to improve.
VALUES	4) The approach and the values that characterize our behavior are based on the "*toyota way*". 5) Management philosophy and a set of principles that represent the most important guide for both business activities *and our own behavior in everyday work. all employees must adhere to these values in their everyday work and in their relationships with others.*

In TMH the production system (TPS) is based on some principles (see Figure 10):

a) Production must take place in accordance with market demands (*just in time*); the Muda waste must be eliminated.

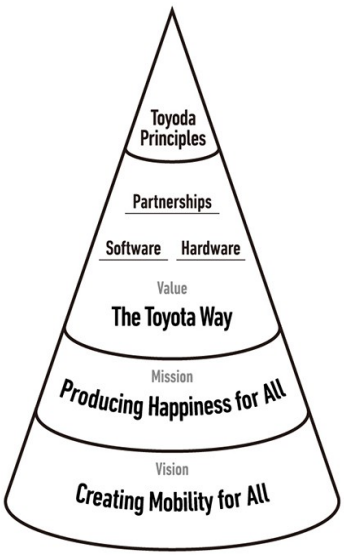

Fig. 10 – Toyota Philosophy in TMH (source Toyota)

b) Built-in quality (*jidoka*). Political analysis of the flows and the removal of constraints: there is a limiting factor that systematically asks the question of where this factor is located and how it is possible to hope for an excellent base for business improvement.

c) Responsibility for the quality of it all (*kaizen*); each fault must be identified. and eliminated immediately. Implementing lean management can be a complex and challenging process, but it can also be very rewarding.

By following these strategies, organizations can improve their efficiency, reduce waste, and improve customer satisfaction by controlling the flows of material, information, and lead time (see Figure 11).

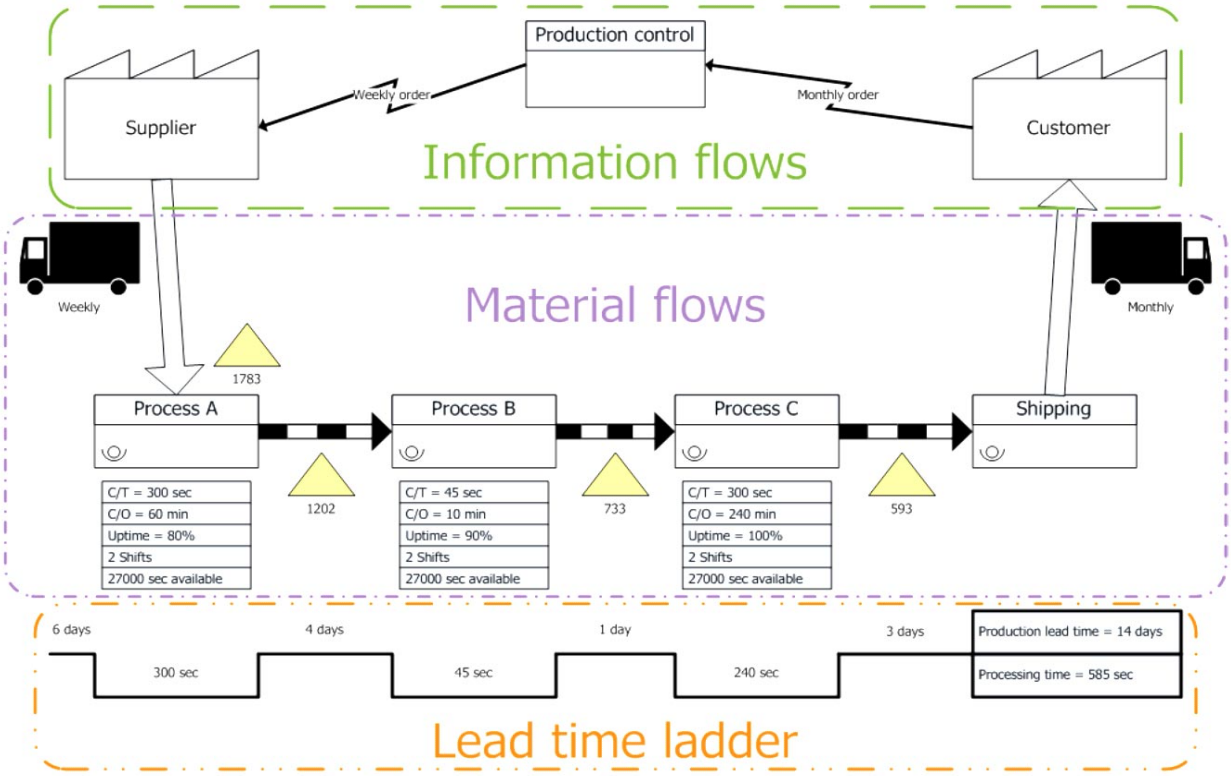

Fig. 11 – The value stream map (source elaboration from Toyota)

The idea of lean management is linked to the Toyota production system a manufacturing philosophy pioneered by the Japanese engineers Ohno and Shingo. Just-in-time production methods are a key element of lean production.

Ohno studied Henry Ford because he reduced waste (see Figure 12) at early Ford assembly plants.

For TMH, lean management is a cultural change, so it is important for senior management to ensure that the necessary resources are available and that the changes are supported throughout the organization. It is important to implement lean management across the entire organization

This will help to build momentum for problem-solving and make the changes more sustainable. Lean management is about empowering people to make decisions and solve

problems. It is useful to measure progress so that it is possible to track improvements and to have good motivation.

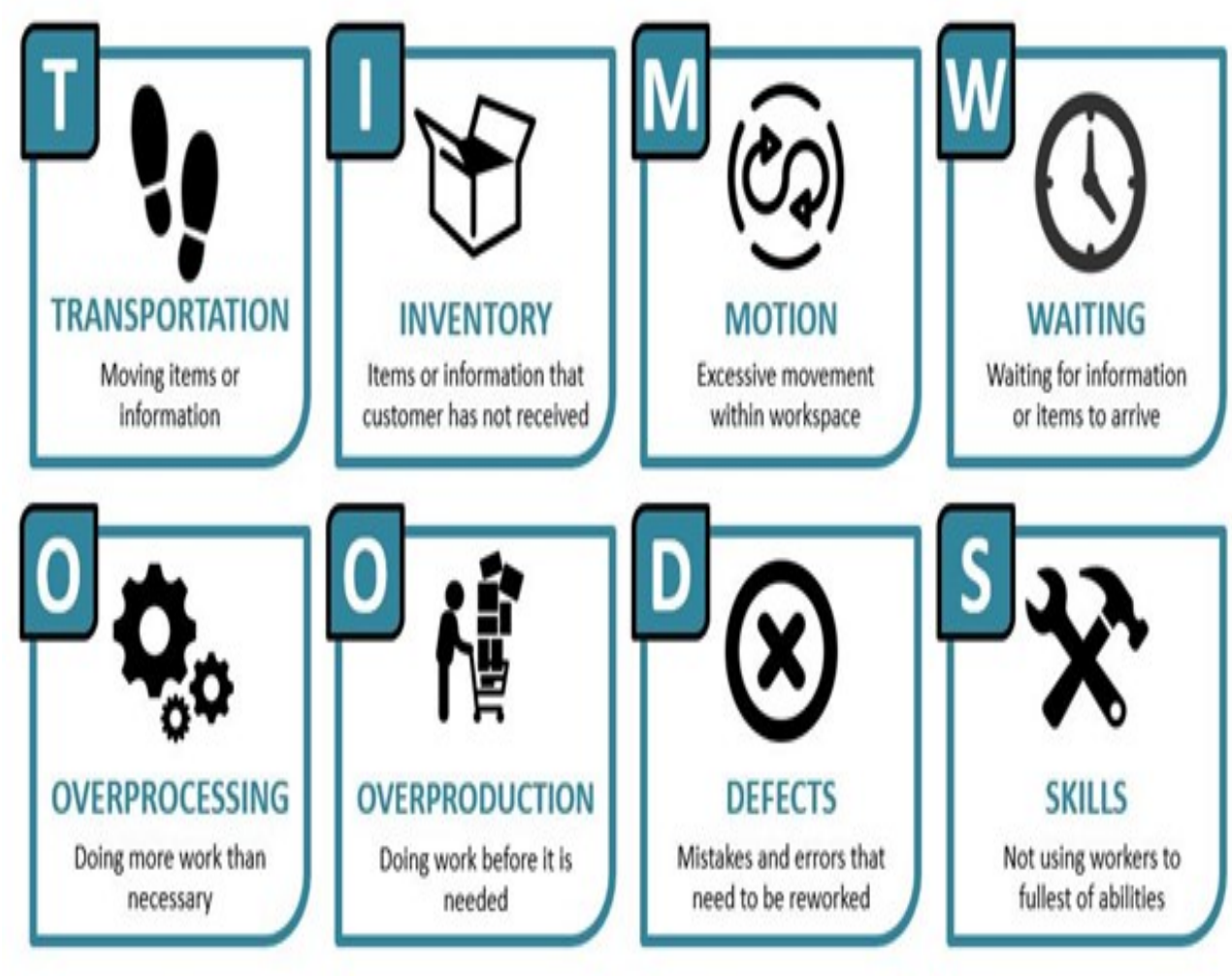

Fig. – 12 The main category of waste (source SSDSI)

5.2 – *Kanban system and pull system in TMH*

In TMH, Kanban is a visual production control system that was developed by Toyota in the 1950s. It is a simple but effective way to manage inventory and prevent overproduction. Kanban cards, which are small pieces of paper, are used to communicate between different stages of the production process. The cards indicate the type and quantity of parts that are needed. It is a pull system, which means that parts are only produced when they are needed. This helps to control production.

Kanban (see Figure 13) has several benefits for reducing waste by ensuring that only the necessary parts are produced; improving efficiency of the production process; improving quality by preventing defective products from being produced, to increase visibility into the production process, which can help to identify and solve problems.

Kanban is a versatile tool that can be used to control production. It is a simple and effective way to improve production efficiency and reduce waste. typically contains the following

information: the part number, the quantity needed, the source of the part, and the destination of the part.

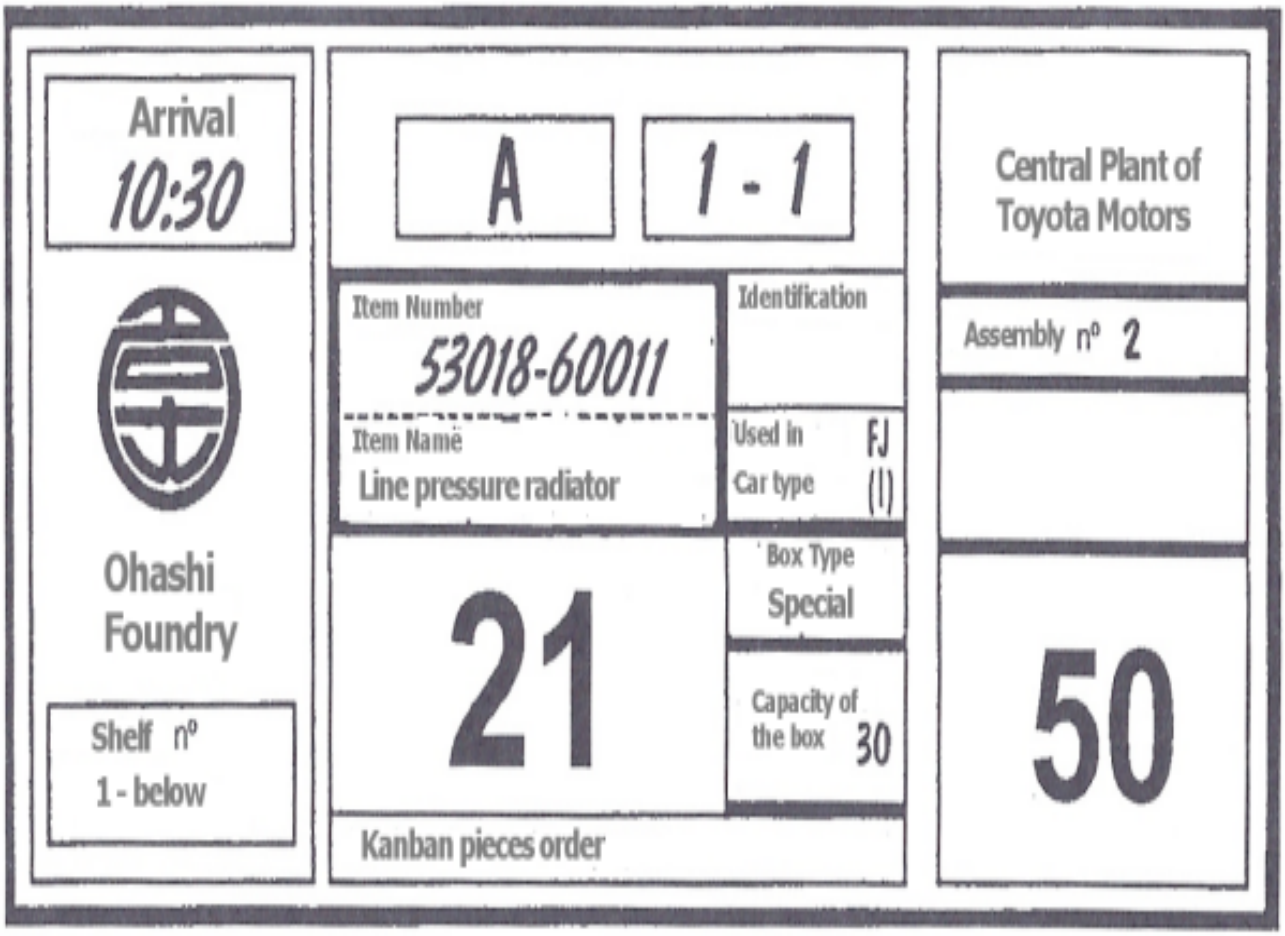

Fig. – 13 Example of Kanban used by Toyota. (Source: Ohno, 1997),

They can be used in a variety of ways, including to control the flow of materials, to track the progress of work, and communicate between different teams. It can be used to manage any type of inventory, including raw materials, work-in-progress, and finished goods.

The key to success is the pursuit of increased productivity through innovation (Toyota's philosophy is based on:

1) identify who the customers are,

2) determine the needs of those customers,

3) translate those needs into the language of the organization,

4) optimize the product features to meet company and customer needs,

5) quality control develops a process that can produce the product,

6) control the flow and Time of cycle (TC) (see Figure 14),

7) quality improvement.

Every product produced by Toyota is designed with the search for quality and every detail is subjected to strict control tests during the entire production cycle. For Toyota, there is the importance of a set of principles: absolute respect for man and the excellent quality of the products.

Fig.14 – The visual control of production ***(source Toyota)***

5.3 – *The global strategy of production, PDCA and tools*

In TMH that quality does not happen by accident and needs to be planned (Prater, 2001, Preite, 2000; Pyzdek, 2000; Qintas *et al*., 1997; Ramarapu *et al*., 1995; Santos *et al*., 2018; Schonberger, 2008; Sinha *et al*., .2019; Upadhye *et al*., 2010; Vais *et al*., 2006; Verrier *et al*., 2016; Wu, *et al*., 2015).

Toyota underlines the importance of problem-solving and the definition of a quality system: procedures manual, work instruction for performing work activities, and database with contains reference documents (standards, forms, information reference).

Fundamental to the improvement process is the PDCA cycle (Plan - Do - Check – Acts in Deming wheel). The complete cycle will be repeated many times until you reach the desired objective (see Figure 15).

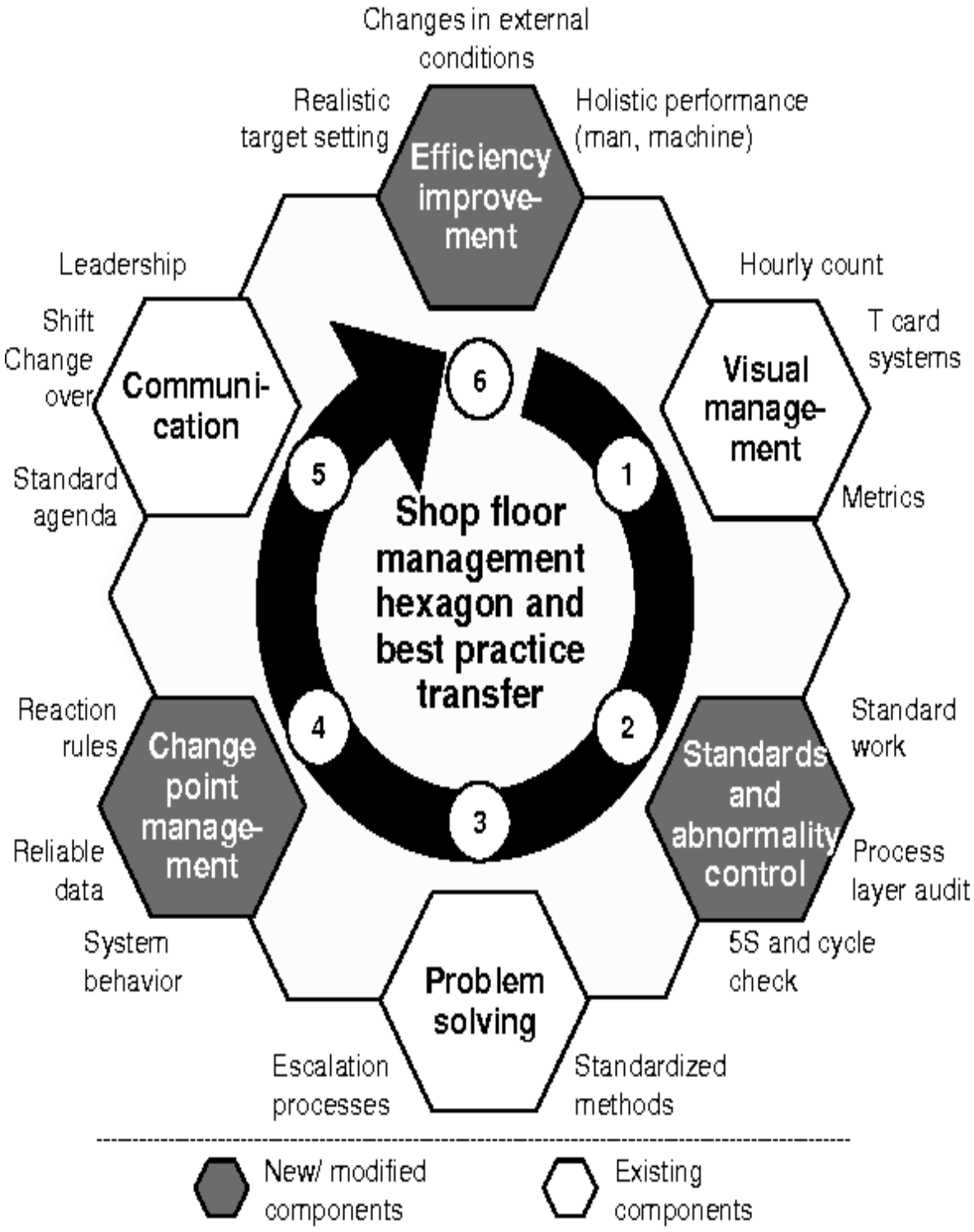

Fig. 15 – The global strategy for quality (source elaboration from Liker)

The customer is a core value for the company as the company's life depends on it. All employers should be aware of this, and the company cannot survive without customers. The culture in the firm is important.

The manager has an important role to control the managerial system and to determine the priorities (see Figure 16).

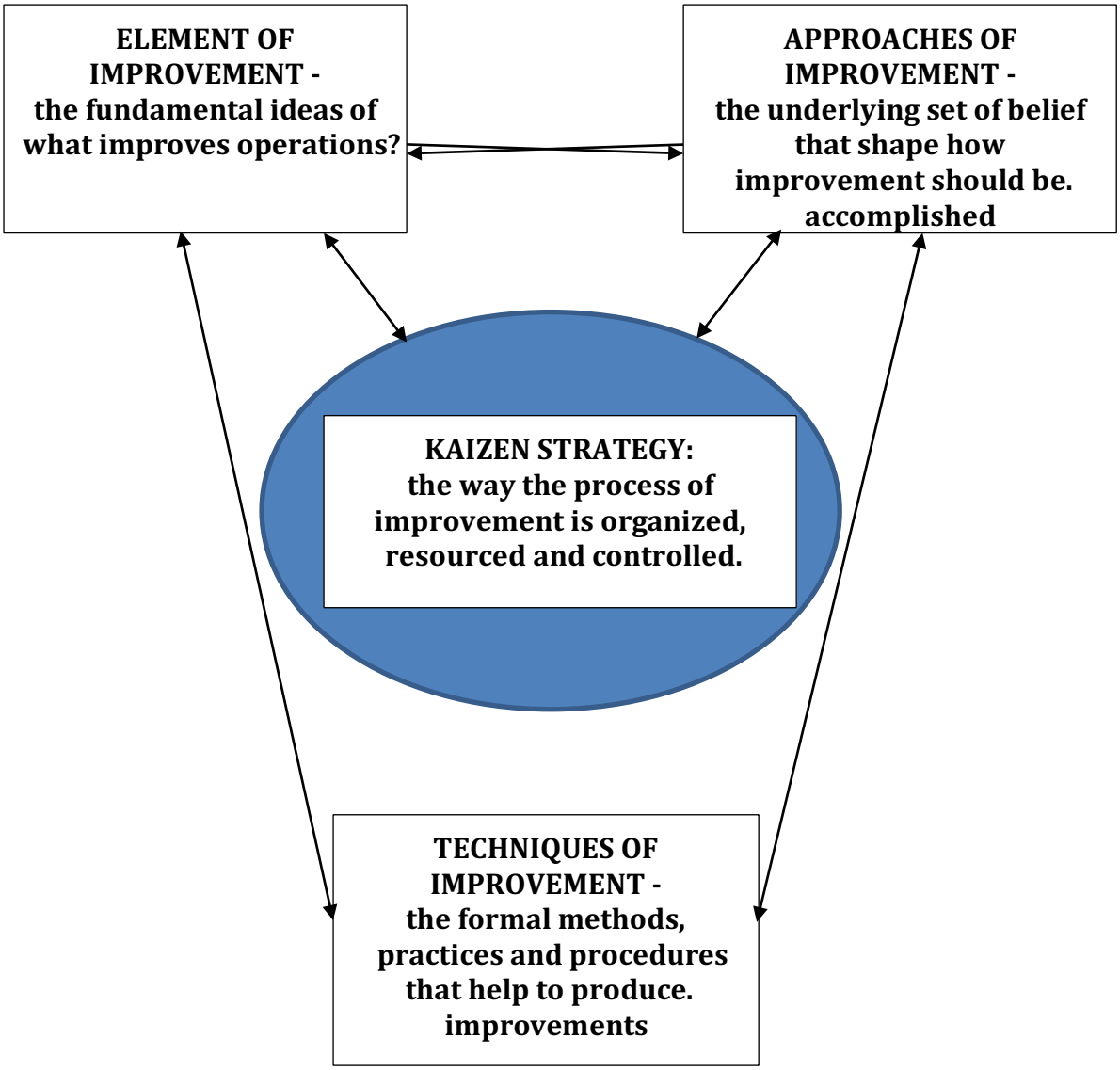

Fig.16 – Kaizen Strategy (adapted from Deming 2000)

In TMH, lean management (Liker 2004; O'Dell *et al* 1997; Piercy *et al*.2015) follows five principles:

- Identify value (What does the customer value? What activities create value for the customer?);
- Map the value stream (How is the product or service created? What are the steps involved in the process?);

- Create a continuous flow (eliminate waste and bottlenecks; make sure that the product or service flows smoothly through the process);
- Pull from the customer (only produce what the customer needs when the customer needs it);
- Continuous improvement (never be satisfied with the status quo; always look for ways to improve the process (see Figure 17).

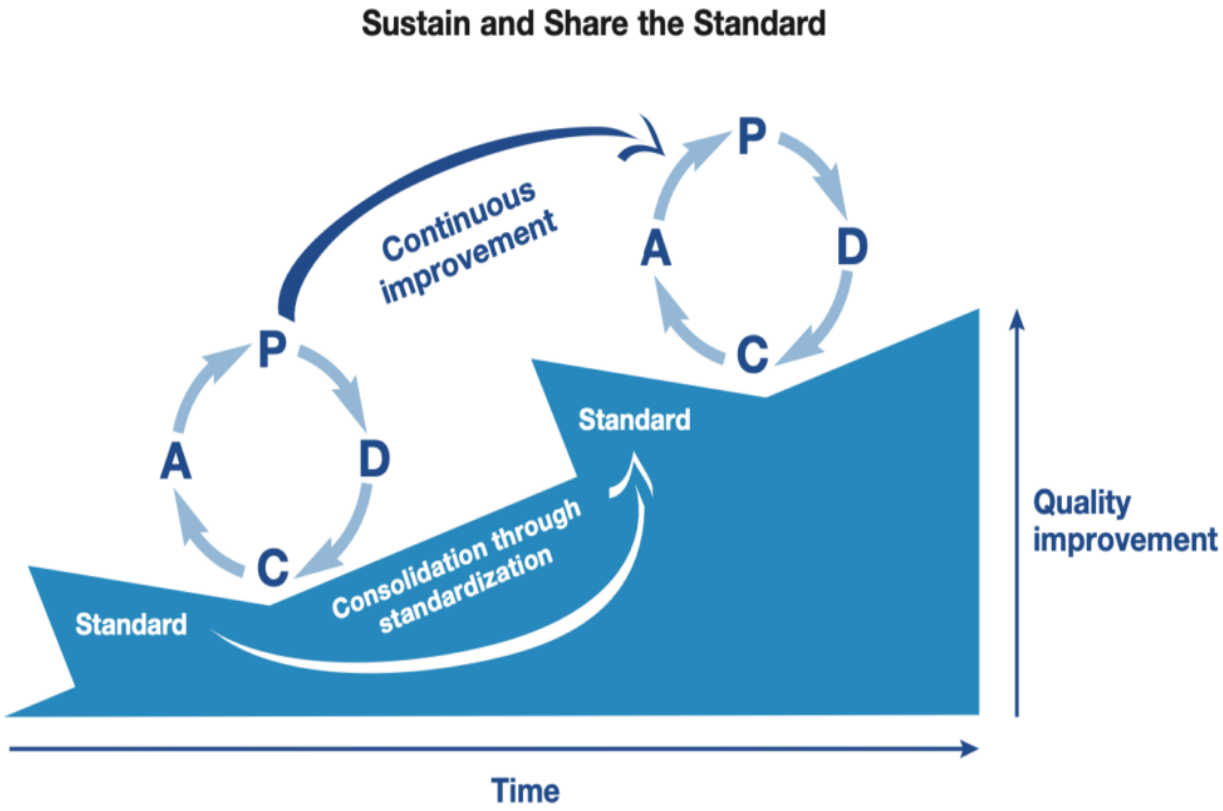

Fig. 17 – The improvement in Toyota Factory
(source. elaboration from Lean enterprise institute)

When these lean principles are combined in business processes and culture, optimal operating systems can be created.

5.4 – *Visual management*

In TMH the tools (Gunawan, 2015; Hall, *et al.*, 1993; Hamel, Prahalad, 1989,1994; Harata, *et al.*, 2012; Hirohisa *et al.*, 2021; Holweg 2007; Kaplan and Norton, 1996, 2001, 2004a, b; Macduffie, 1995; Mahaboob Basha *et al.*, 2020; Maxwell *et al.*, 1998) permit to solve almost 95% of the real problems, while the other 5% of the problems requires specific skills. Particularly useful is the use of several key questions (5W + 1H -initials of the words in English - Who? What? Where? When? Why? How?). These words represent six references that is useful to consider for any problem or situation. The control card is used to check if a process is in control or out of control.

The Obeya room permits the visual control of the performance (see Figure 18).

It is important for the quality management of monitoring the standards and business procedures (the idea of) "*do the right thing the first time*". The performance standard is "*zero defect*". Among the main indicators, are customer satisfaction, financial performance, speed, lead time, quality, failures just in time, and learning ability. The innovation is based on strong improvement and continuous improvement (see Table 13).

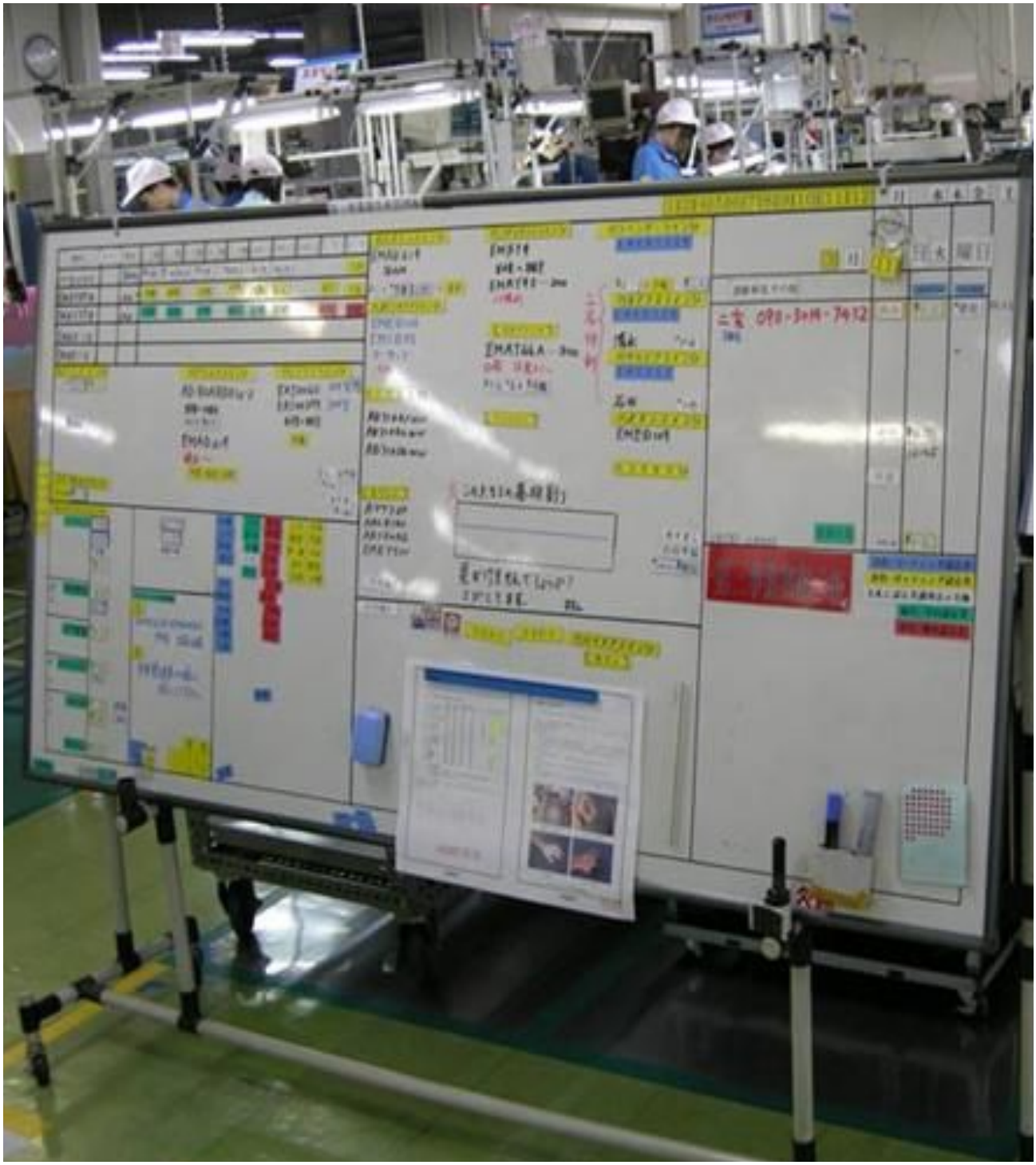

Fig.18 – Obeya Room in Toyota (source Printest)

Tab. 13 – Features of breakthrough and continuous improvement (source our elaboration)

	STRONG IMPROVEMENT	CONTINUOS IMPROVEMENT
EFFECT	**Short t-term but dramatic**	***Long-term and lost-lasting but undramactic***
LEVEL	**Big steps**	***Small steps***
TIME-FRAME	**Intermittent and nonincremental**	***Continuos and incremental***
CHANGE	**Abrupt and volatile**	***Gradual e costant***
INVOLVEMENT	**Select a few 'champion'**	***Everybody***
APPROACH	**Individualism, individual idea and effort**	***Collectivism, group effort, system approch***
STIMULUS	**Technological breakthrougs, new invention new theories**	***Conventional know-how and state of art***
RISK	**Concentered- 'all eggs in One basket'**	***Spread- many projects simultaneously***
PRATICAL REQUIMENTS	**Requires large investment but Little effort to mantain it**	***Requires little investment but great effort to maintain it***
EFFORT ORIENTATION	**Technology**	***People***
EVALUATIN CRITERIA	**Result for profit**	***Process and efforts for better results***

There is the search for the optimization and synchronization of all the stages of production to better manage the resources and to ensure the maximum quality of the final product.

6 – Conclusion

In Toyota Material Handling (Ohno, 1988; Cortiglioni *et al*., 2017) there is an evolution of the methodology of the Toyota Production System (TPS) (see Figure 19) developed by Toyota in the 1950s. It is based on the principles of (I) *Jidoka* (intelligent automation) and (II) *Just-in-Time*

(JIT) production. Jidoka refers to the ability of a production system to stop automatically when a defect is detected, while JIT refers to the production of goods only when they are needed. Important in TMH are core values (III), 5S/2S (IV), standardized work (V), visual management (VI) and Kaizen (VII) for the elimination of the waste (muda) (final objective).

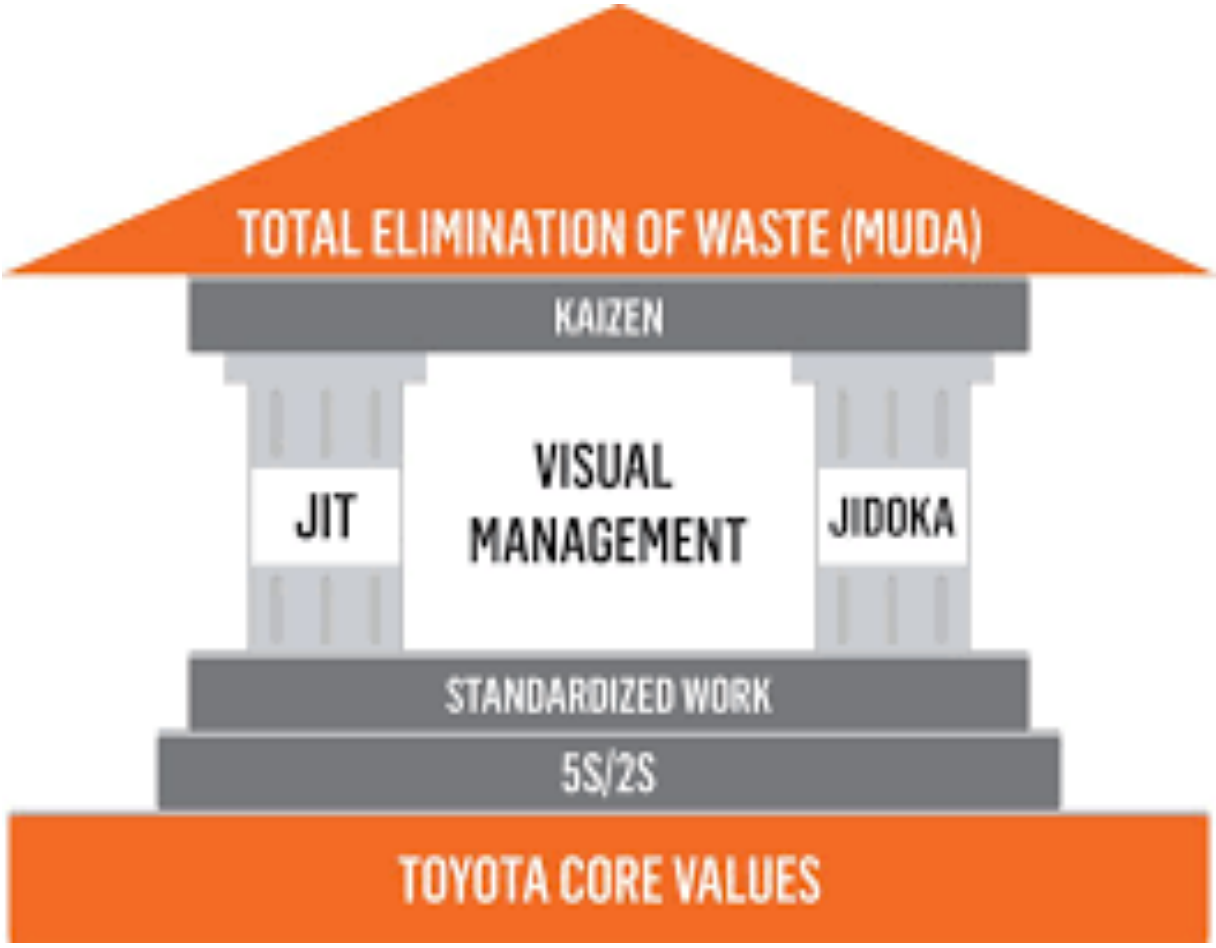

Fig. 19 – The lean strategy in Toyota material handling
(source Toyota Material Handling)

6.1 – *The first research question*

Concerning the **first research question**: "***RQ1:*** *How to Decode the DNA of the strategy of the Toyota Production System?"* we discover:

a-FIRST, the result of our research shows how the main strength of TPS is based on the following principles and the use of a set of instruments for development (see Table 14).

I) *Eliminate waste:* TPS seeks to eliminate all forms of waste, including overproduction, waiting time, unnecessary transportation, unnecessary processing, defects, and inventory.

II) *Create a flow:* TPS seeks to create a smooth flow of production so that goods are produced only when they are needed and in the right quantity.

III) *Jidoka:* TPS relies on intelligent automation, to stop the production line automatically when a defect is detected. This prevents defective products from being produced and shipped to customers.

IV) *Just-in-Time:* TPS relies on JIT production, which means that goods are produced only when they are needed. This minimizes inventory and ensures that goods are produced in the right quantity.

Tab. 14 – Main dimension for strategy, control, and assessment in Toyota Production System (source our elaboration)

	MAIN DIMENSION - TOOLS	IMPORTANCE
1	**Value stream mapping (vsm)**	*****
2	**Standards**	*****
3	**Visual management**	*****
4	**Continuous improvement / kaizen**	*****
5	**Performance measurement**	****
6	**Smed**	***
7	**Problem-solving**	***
8	**Maintenance**	****
9	**Flow/ pull system / balancing**	****
10	**Management commitment**	****
11	**Versatility**	***
12	**Diagnosis**	**
13	**Kaizen week**	***
14	**Customer satisfation**	****
15	**Inventory and wip level**	***
16	**Team work and motivation**	****
17	**Safety, enviroment, clenaess and order**	****
18	**Sceduling system**	***
19	**Space use, material movement and production flow**	****
20	**Commitment to quality**	***
21	**5s**	*****
22	**Spaghetti diagram**	****
23	**Kamban board**	*****
Rating (* Low -*** High)**		

b - SECOND, the DNA of the strategy and the Corporate Social Responsibility in TMH (see Table 15) permits numerous benefits for the company to become one of the leading manufacturers in the world.

Tab. 15 – The DNA of the Strategy of TMH

THE DNA	
Vision and philosophy	Value creation is based on the Toyoda precepts and basic philosophy, we aim to contribute to making the earth a better place to live, enriching lifestyles and promoting a compassionate society. Toyota encapsulated the spirit of founder Saki Chi Toyoda in the Toyoda precepts, which serve as Toyota industries' corporate creed and upon which our basic philosophy is based.
Toyoda precepts (corporate creed)	Always be faithful to your duties, thereby contributing to the company and to the overall good. Always be studious and creative, striving to stay ahead of the times. Always be practical and avoid frivolousness. Always strive to build a homelike atmosphere at work that is warm and friendly. Always have respect for spiritual matters and remember to be always grateful.
Basic philosophy and corporate social responsibility	
Respect for the law	Toyota industries is determined to comply with the letter and spirit of the law, in Japan and overseas, and to be fair and transparent in all its dealings.
Respect for others	Toyota industries is respectful of the people, culture, and traditions of each region and country in which it operates. It also works to promote economic growth and prosperity in those regions and countries.
Respect for the natural environment	Through its corporate activities, Toyota industries works to contribute to regional living conditions and social prosperity and strives to offer products and services that are clean, safe, and of high quality.
Respect for customers	Toyota industries conducts intensive product research and forward-looking development activities to create new value for its customers.
Respect for employees	Toyota industries nurtures the inventiveness and other abilities of its employees. It seeks to create a climate of cooperation so that employees and the company can realize their full potential.

In TMH among the critical elements in the implementation of a methodology to improve the main weaknesses are:

a) a clear vision of the goals and mission policy for sustainable behavior (see Figure 20);

b) understanding of the culture to obtain them;

c) the definition of the set of behaviors and profiles required to achieve the desired results.

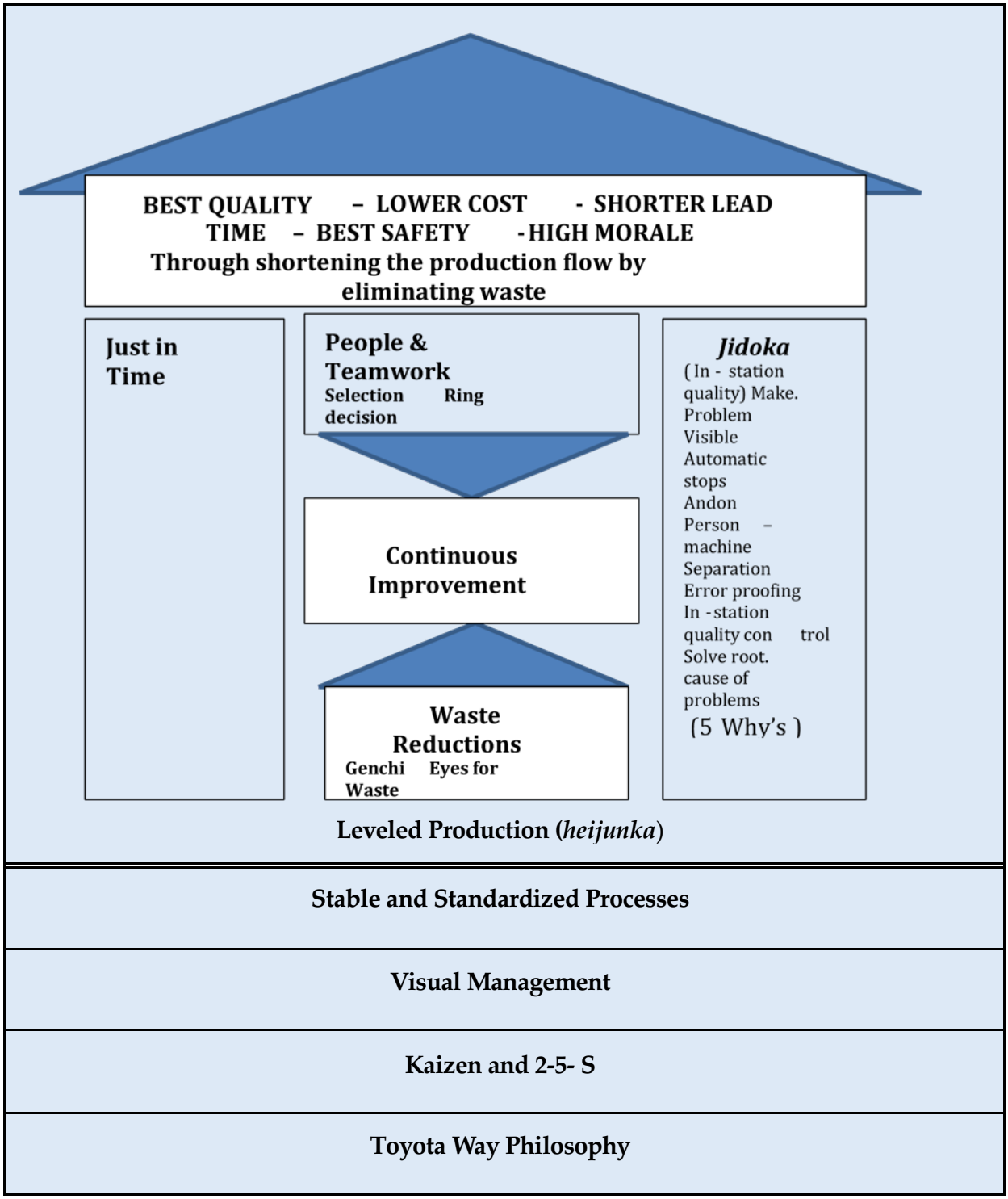

Fig. 20 – The DNA of Toyota (source: our elaboration from Toyota)

Some of the key principles of Kaizen in TMH are:

1) *Identify and solve problems.* The first step to improving efficiency is to identify problems. This can be done through observation, measurement, and data analysis.

2) *Make small improvements*. Instead of trying to make big changes, Kaizen focuses on small improvements that can be easily implemented.

3) *Get everyone involved*. Kaizen is a process that involves all employees of TMH. Everyone must be involved in the improvement process, and everyone must be motivated to find ways to improve.

4) *Be persistent*. Kaizen is a continuous process. There is no point where you can say "*we're done*". Kaizen must be a continuous process of improvement. Kaizen is an effective method for improving efficiency and can lead to numerous benefits for the company, including:

5) *Cost reduction.* In TMH Kaizen helps to reduce costs by eliminating waste and improving the efficiency of processes.

6) *Quality improvement.* Kaizen can help to improve the quality of products and services by eliminating errors and improving customer satisfaction.

7) *Improved employee ability and motivation.* Kaizen can help to improve employee morale by involving them in the improvement process and giving them the opportunity to contribute to the success of the company.

***c -THIRD*,** The results of the first question are coherent with past research (Ohno, 1988; Liker, 2004; Deming, 2000; Riva, 2006, 2012; Mella, 1997, 2005, 2012, 2014, 2015, 2017; Pilotti, 2011, 2019; Pilotti, and Rinolfi, 2022a,b; Riva and Pilotti, 2021a; Shingo, 1981; Cortiglioni al., 2017; Womack and Jones, 1994; 1996).

6.2. – *The second research question*

Concerning the second research question: **RQ2:** "*How is it possible to develop a strategy and control system based on TPS (Toyota Production System)?"* we find:

A-*FIRST*, it is important to define value from the customer's perspective and use visual management tools; it can help to track progress, identify problems, and communicate effectively in the team. Some common visual management tools include:

I) Kanban Boards,

II) Value Stream Maps,

III) Spaghetti Diagrams,

IV) the control of Time Cycle (actual and target) by Visual Scoreboard.

Relevant is setting clear goals and objectives and measuring the progress and continuously improving (see Table 16). Lean thinking is all about continuous improvement and eliminating waste.

Tab. 16 – Control system in lean management i (source our elaboration)

KPI's CONTROL DIMENSION	FOCUS
COST	Seeks the lowest price compared to competitors, the lowest total production cost, or the highest production capacity.
NEW PRODUCTS	Entry of products into a specific market aiming to attract new consumers and/or retain current ones.
QUALITY	Zero-defect manufacturing or manufacturing of durable products.
FLEXIBILITY	Quick changes in product design, quick introduction of new products, quick changes in production volume, broad variety of products, or quick changes in product mix.
DELIVERY	Quick delivery, or reliability in timely deliveries.
OVERTIME	The amount of time someone works beyond normal working hours.
INVENTORY TURNOVER	The number of times a company's inventory is sold and replaced over a period of time.
LEAD TIME	The period of time that it takes for goods to be delivered after a customer has ordered them.
SETUP	Period during which production is interrupted while the manufacturing equipment is adjusted to another product.

b-SECOND, Toyota's strategy is based on the following dimension:

-i) Continuous improvement: Toyota is constantly looking for ways to improve its products, processes, and operations. This is known as kaizen in Japanese.

-ii) Lean manufacturing: it uses lean manufacturing principles (see Figure 21) to reduce waste and inefficiency in its production processes. This helps the company to produce high-quality products at a competitive cost.

-iii) Sustainability: The company has set a goal of reducing its greenhouse gas emissions by 50% by 2050. Toyota is also working to develop more sustainable materials and manufacturing processes.

-iv) Innovation: Toyota is a leader in innovation and Kaizen (see Table 17). The company has developed several groundbreaking technologies, including the hybrid electric vehicle (HEV), the fuel cell vehicle (FCV), and the self-driving car.

-v) Customer focus: The company conducts extensive research to understand what customers want and need. Toyota then uses this information to develop products and services that meet those needs (Cortiglioni *et al*., 2017).

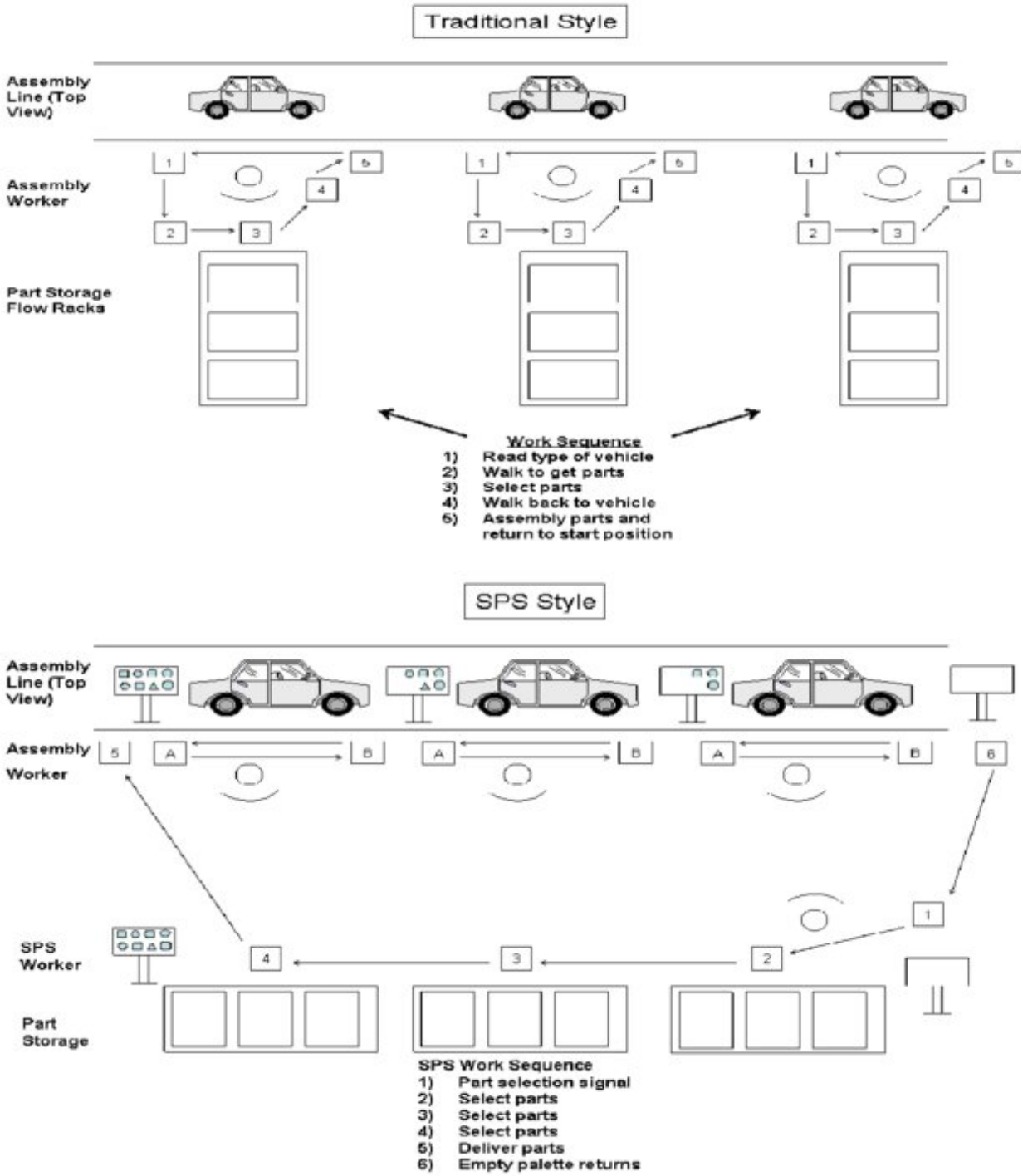

Fig. 21 – The line production system in Toyota (source Corakci 2008)

c – *THIRD*, The results of the second question are coherent with past research (Collis, 2016; Ohmae, 1982; Womack and Jomes, 1990; Riva and Pilotti, 2019, 2020; Pilotti and Rinolfi, 2022a,b; Mella, 2014, 2018, 2021,a.b; Gazzola and Colombo, 2014; Graziadei 2006; Gazzola and Mella,

2003, 2006, 2017; Gazzola *et al*., 2020; Pilotti, 2011, 2017, 2019; Riva, 2007a,b; 2008; Deming 2000; Spear and Bowen, 1999).

Tab. 17 – Principle in lean management in TMH (source our elaboration from TMH)

	PRINCIPLES	ACTION
1	**CHALLENGE:**	To pursue a long-term vision and face all challenges with the courage and creativity necessary to achieve that vision.
2	**KAIZEN:**	Constantly to improve the company's activities, always focusing on innovation and development. indeed, since no process can be defined as perfect, there is always the possibility of improvement
3	**GENCHI GENBUTSU:**	To practice "genchi genbutsu", which means "going to the source" to discover the facts on which to make the right decisions, gather consensus and achieve the set goals.
4	**RESPECT:**	To respect others, we continually strive to understand others, assuming our responsibilities and committing ourselves to building relationships of mutual trust.
5	**TEAMWORK:**	To encourage personal and professional growth, share development opportunities and aim for the maximum individual and team performance.

The limit of this study is to analyze only a case of lean management strategy; future research can analyze other cases and factories. This methodology can also be applied to other areas, such as service industries and healthcare. It is a valuable tool for any organization that seeks to improve its efficiency and productivity. TMH has developed a method for improving efficiency based on continuous improvement and it is based on the concept that every process can be improved in some way.

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