

# The Current Status of Lean Manufacturing Maturity of Taiwanese Enterprises

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## ABSTRACT

*This paper discusses Taiwanese enterprises' current promotion of lean activities through the maturity model. It aims to determine how the enterprises promoting lean activities consider operational performance benefits and future projects for lean management. Adopting the purposeful sampling research method, this study selected 18 Taiwanese manufacturers that promote lean management as the research samples. In the maturity assessment, the supplier integration dimension had the lowest performance, while the customer dimension had the best. After adopting lean management, cost performance showed the best performance regarding the study subjects, while overtime showed the worst performance.*

*Based on the actual cases in Taiwan, this study contributes an understanding of the maturity of lean activities of Taiwanese enterprises while providing management contributions. The findings offer self-assessment tools and recommendations for promoters to evaluate lean manufacturing maturity.*

**Keywords: maturity model; lean manufacturing; operational performance**

## 1. INTRODUCTION

Germany's introduction of Industry 4.0 in 2011 has driven global manufacturers into a competition similar to an arms race. After a development period, Buer et al. (2018) proposed that combining Industry 4.0 and lean management can balance productivity and flexibility. While lean production paves the foundation for Industry 4.0, Industry 4.0 facilitates lean management through technology (Dombrowski et al., 2017). Lean management is a management system developed by Toyota Motor based on its 30

years of study since the 1950s. From a process and system implementation perspective, it covers continual, intensive process improvement, Kanban management, and a zero inventory system. It is supported by a high degree of standardized and level production management.

Taiwan's industries are export-oriented. Product profits have decreased due to global market competition, the increasing price of raw materials, and rising labor costs. The lean management model is an effective solution for companies to cope with this circumstance. The most successful case of lean management in Taiwan is the globally well-known A-team system of the bicycle industry. Various industries in Taiwan have followed this example due to its success. Lean management can have a positive impact on the business performance of enterprises, including the reduction of process variation, reduction in waste generation, and shortening of rework time. This reduces production costs and delivery cycle and improves process flexibility, output consistency, and quality. This study explored the status of lean management in Taiwan as it is currently promoted by several organizations. We adopted the organizational maturity model as an objective method to understand the operational improvement process of organizations in previous studies (Paulk, 1993). Furthermore, this paper investigates whether organizations promoting lean management activities have the demand or willingness to implement new lean management agendas and activities in addition to current practices.

## 2. LITERATURE REVIEW

### 2.1 Lean management

After Jim Womack and other professors from the Massachusetts Institute of Technology (MIT) published the book *"The machine that changed the world"*, the lean production system became popular worldwide, leading to the publishing of relevant studies and books. The basic definition of lean management is to gain more results with less effort (Rymaszewska, 2014), brief yet powerful and enlightening. According to Womack (1990), lean production uses fewer resources than mass production. It utilizes only half of the workforce, half of the manufacturing space, half of the tool investment, half of the engineering time, and half of the time to develop new products. Shah and Ward (2003) highlighted that high-quality production systems and the continual elimination of waste form the fundamental basis of lean production. As an extensive management method, lean management is deemed a collection or a system of management tools and even a philosophy or ideology. When an enterprise/organization promotes lean management activities, it changes how it produces and inspects products, i.e., how its employees work, and it begins to transform its organizational culture. Therefore, it is necessary to pay continuous attention to corporate culture (Wilson, 2015). There are several aspects of lean production, including waste elimination, using relevant principles to determine the associated conditions of products or services, and the predictability and stability of demand.

### 2.2 Maturity model

The Capability Maturity Model (CMM), designed for the system software industry, has been further developed and applied to other fields. Capability Maturity Model Integrated (CMMI, 2002) is a revised version after the successful development of CMM, which is no longer limited to software development maturity. Based on a system and software engineering framework, CMMI has added and integrated the capability maturity models of various professional fields. It can be applied to organizations of any size to facilitate their process improvement.

## 3. METHODS OF RESEARCH

By adopting a purposeful sampling research method, this study examines enterprises/organizations promoting lean management as the research subject. This study explores the current implementation

practices of lean improvement activities by such enterprises, enterprises' maturity, central performance, willingness to continuously promote lean management, and their subsequent project requirement for lean management by conducting a survey questionnaire.

### 3.1 Questionnaire design

The questionnaire covered company demographics and three major parts, including (1) a maturity survey; (2) a survey on the impact of lean management implementation on operational performance; and (3) a survey on the enterprises' current promotion of lean activities.

#### Part 1: A maturity survey

The questionnaire designed by Bentoa and Tontini (2018) was taken as the primary reference for this part. Part 1 of the present study's survey was divided into eight dimensions and 38 questions, as shown in Table 3. The maturity level was divided into five grades, as defined in Table 1.

**Table 1. Definition of Maturity Level**

LEVEL	Description	Content
1	Not implemented or implemented unofficially	The process has not yet been implemented or is being implemented unofficially, and the results are unstable.
2	Implemented officially	The process is implemented officially with an implementation plan.
3	Implemented and documented, with occasional failure	The process has been officially deployed (documented), but certain implementation deficiencies exist.
4	Implemented and documented, with set control indicators	The process has been comprehensively implemented in one or several areas and is controlled by established indicators.
5	Implemented, controlled, and continuously improved	The process has been fully implemented, management indicators have been set, effective results have been achieved, and continuous improvement has been made over the past 12 months.

Part 2: Investigating the impact on operational performance

This part evaluated companies' operational performance (indicator) in promoting lean management, as shown in Table 2. A five-point Likert scale was used for relevant evaluation, including strongly disagree (check 1), disagree (check 2), fair (check 3), agree (check 4), and strongly agree (check 5).

**Table 2. Description of Operational Performance (Indicator)**

Operational performance (indicator)	Description
Cost	Seeking the lowest price, the lowest total production cost, or the highest production capacity compared to competitors.
New product	Launching products in specific markets to attract new consumers and retain the existing ones relevant to products with new features and functions.
Quality	Zero-defect manufacturing or high-reliability product manufacturing.
Flexibility	Rapid changes in product design, rapid introduction of new products, rapid changes in product volumes, extensive changes in product categories, or rapid changes in product assortment.
Delivery time	Reliability for fast or timely delivery.
Overtime	Reducing overtime hours.

Inventory turnover	Number of sales or replacements of the company's inventory over a period of time.
Lead time	Time required for the delivery of goods upon customer order.
Shutdown for line switching	Mold and line switch for manufacturing equipment during production outage.

Part 3: A survey on the enterprises' current promotion of lean activities

This part investigated the relevant matters currently propelled by organizations in promoting lean activities and their future development. The investigated activities were divided into the following eight items: (1) Workplace revitalization activities; (2) workplace maintenance; (3) operation improvement; (4) logistics improvement; (5) equipment improvement; (6) quality improvement; (7) early improvement; and (8) green lean management.

#### 4. RESEARCH RESULTS

Industrial visits, interviews, and questionnaire completion were conducted. A total of 18 questionnaires were collected from June 2022 to August 2022, including eight from large-size enterprises, six from medium-size enterprises, and four from small-size enterprises.

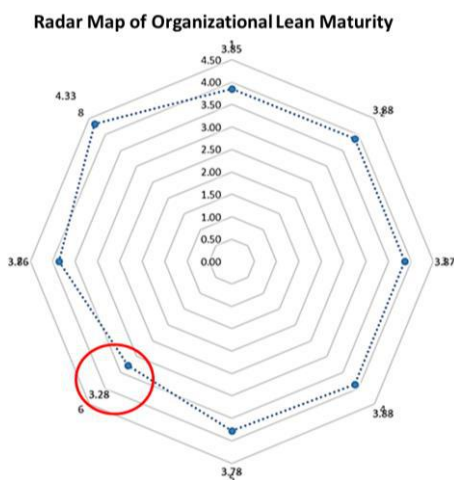
**Table 3 Statistical Table of Organizational Lean Maturity**

Item	Coding	Content	All	Small-size	Medium-size	Large-size
Strategic planning (SP)	SP1	Steadily pushing forward the strategic planning based on the concept of long-term development.	3.6111	2.75	3.5	4.125
	SP2	Consistent objectives for employees and the organization.	3.7778	3	4	4
	SP3	Implementation of the organization's objectives by all departments.	3.9444	3.25	4	4.25
	SP4	Communicating strategies and objectives to everyone in the organization.	4.0556	3.5	4.1667	4.25
Quality of source (QS)	QS1	Using automatic equipment that can detect defects to avoid defective products.	3.7222	3.5	4	3.625
	QS2	Introducing error-proof devices on the production line.	4.1111	3.5	4	4.5
	QS3	Ensuring that the property and information are used correctly and in compliance with specifications during the process.	4	3.5	4.1667	4.125
	QS4	Achieving standardization through OPL or job specifications developed by the operators.	3.8889	4	3.5	4.125
	QS5	Applying SPC systematically to reduce variation in product quality.	3.6667	2.5	3.6667	4.25
Process and	PT1	Continuous material movement and information	3.7222	3	4	3.875

Item	Coding	Content	All	Small-size	Medium-size	Large-size
tool (PT)		flow to eliminate material loss and visualize problems.				
	PT2	Improving the lead time to increase flexibility and pick small batches.	3.8889	3.25	4	4.125
	PT3	Routine cleaning, inspection, lubrication, and other maintenance on the machine by operators to eliminate production downtime.	4.0556	3.75	4	4.25
	PT4	Systematically ensure that customers (internal and external) only receive the goods they need at the right time and quantity to avoid excessive production waste.	3.7222	3.75	3.6667	3.75
	PT5	Workload balancing and the overall allocation of orders within a period to stabilize production and eliminate instability in the production plan.	3.5	2.5	3.5	4
	PT6	Carrying out 5S activities to maintain the environment, ensure the availability of necessary materials and tools, and visualize problems.	4.1111	4.25	4.1667	4
	PT7	Ensuring that new equipment is only used after proper testing and operational training to avoid breakdowns and interruptions.	4.0556	3.5	4.1667	4.25
Problem-solving (PS)	PS1	Visualized management, in which inspections and result tracking are conducted visually to help identify problems.	4.0556	3.75	4.5	3.875
	PS2	Building a production line that can communicate problems and requesting help to solve problems through the audible or visual warning system.	3.8333	3.25	4.3333	3.75
	PS3	Building a mutual aid chain to solve problems quickly.	3.8889	3.25	4	4.125
	PS4	Encouraging everyone to observe where the problem occurs in person during problem-solving.	3.8333	3.25	4	4
	PS5	Building a culture of problem observation, raising the question "why" five times, and making decisions based on facts and data.	3.7778	3.25	3.6667	4.125
Personnel (PP)	PP1	Ensuring that the leaders deeply understand the work during leadership development so they can mentor others.	3.8889	3.25	4.1667	4
	PP2	Ensuring leadership development.	3.7778	3.25	4.1667	3.75
	PP3	Instructing employees to understand the work to be completed and the expected results during personnel development.	3.8889	3.25	4.1667	4
	PP4	Instructing employees to use tools correctly and solve problems together during personnel development to build organizational learning.	3.6111	2.75	3.8333	3.875
	PP5	Frequent monitoring of the operation process by leaders so that they can raise questions and instruct employees through observation.	3.7222	2.75	4.1667	3.875
Supplier integration (SI)	SI1	Suppliers' participation in the development of new products.	3.3889	2.5	3.1667	4
	SI2	Suppliers' participation in the strategic planning of the company.	2.8333	2.5	2.5	3.25
	SI3	Suppliers' participation in reducing the delivery time	3.3333	2.5	3.8333	3.375

Item	Coding	Content	All	Small-size	Medium-size	Large-size
		of raw materials and reducing inventory.				
	SI4	Standards of selecting, evaluating, and setting criteria for the re-evaluation of suppliers.	3.5556	2.5	3.8333	3.875
Continuous improvement (CI)	CI1	Considering all alternatives through decision-making and holding group discussions to seek consensus on the issues and possible solutions.	3.7778	2.75	4	4.125
	CI2	Reflecting on and making continuous improvements in processes, monitoring variations, analyzing deviations, and taking measures to prevent them from reoccurring.	3.8333	2.75	4	4.25
	CI3	Encouraging learning and prioritizing minor improvements over major changes.	4.0556	3.5	4.1667	4.25
	CI4	Carrying out improvement activities.	3.7778	2.75	3.8333	4.25
Customer dimension (CF)	CF1	Product development to meet the demand of internal customers.	4.2778	3.5	4.5	4.5
	CF2	Considering the needs of external customers during product development.	4.4444	4	4.5	4.625
	CF3	Regularly contacting and discussing issues related to developing new products with external customers.	4.3333	3.25	4.5	4.75
	CF4	Regularly contacting and discussing with internal customers on issues related to process improvement.	4.2778	3.5	4.3333	4.625

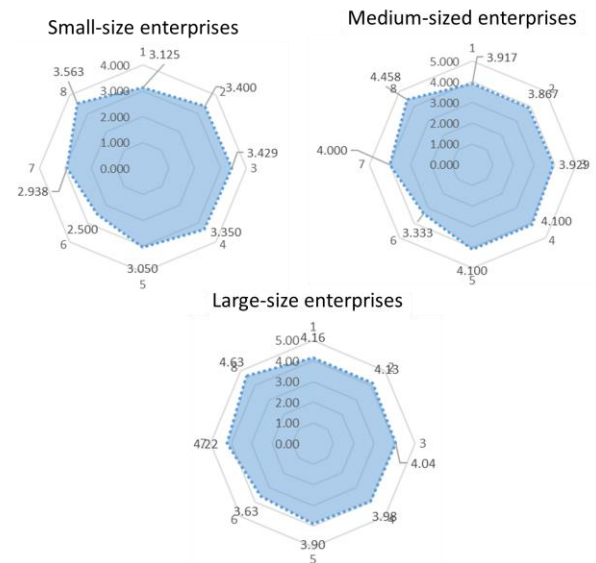
Figure 1 shows supplier integration dimension had the lowest average score with a large gap. This indicates that the resource input and capability of industrial supply chain integration in Taiwan are poor. Regarding supplier dimension, the sub-item with the lowest score was "suppliers' participation in the strategic planning of the company," indicating that Taiwanese enterprises seldom make the content of their strategies available to their suppliers.



**Figure 1 A Radar Map of Organizational Lean Maturity**

Customer dimension performance was good, which also shows that Taiwan's industries can meet the high

customization needs of customers to gain competitiveness. Among them, the sub-item with the highest score was "considering the needs of external customers during product development," demonstrating that Taiwanese enterprises have realized the need to set customer-focused operating principles to meet market demands.



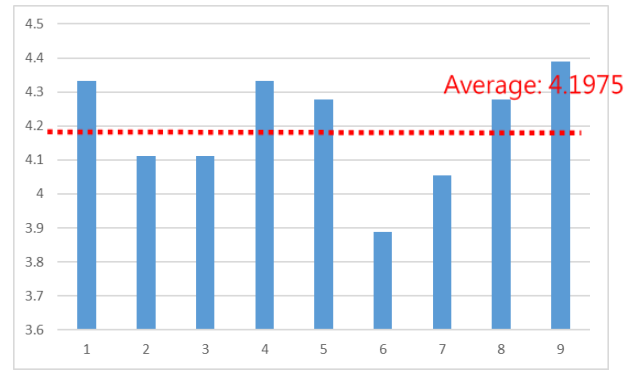
**Figure 2 Radar Map of Lean Maturity of Various Organizations**

Comparing the maturity between large-, medium-, and small-size enterprises shown in Figure 2, supplier integration was ranked the lowest regardless of company size. Furthermore, the item with the second lowest score for small-size enterprises was continuous improvement, indicating that these enterprises lacked long-term impetuses to invest in improvement activities. The maturity of the human resource dimension was also low, which is consistent with the common issues, such as workforce quality and turnover, faced by small-size enterprises. Regarding medium-sized enterprises, the quality of source and strategic planning had the second and third lowest scores, respectively. For large-size enterprises, problem-solving and personnel had the second and third lowest scores, respectively.

**Table 4. Table of Lean Maturity Items to be Strengthened by Each Type of Organization**

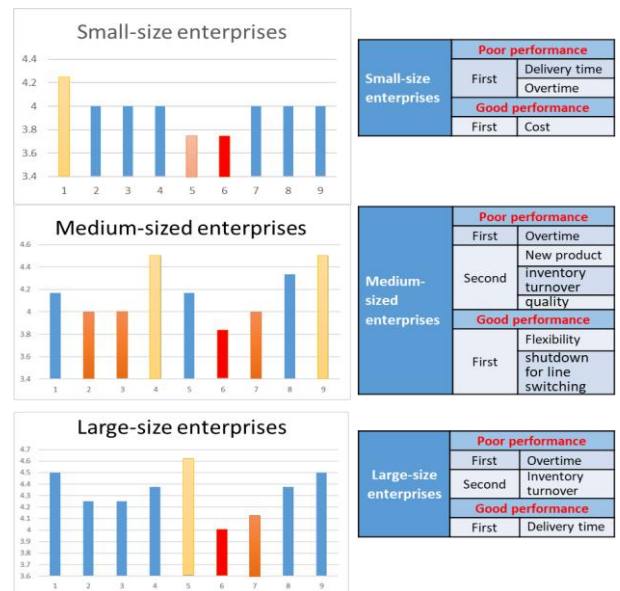
Low maturity	First	Second	Third
Small-size enterprises	Supplier integration	Continuous improvement	Personnel
Medium-sized enterprises	Supplier integration	Quality of source	Strategic planning
Large-size enterprises	Supplier integration	Problem solving	Personnel

The participating companies indicated that good performance after adopting lean management was observed in (1) cost performance; (2) flexibility performance, and (3) results of shutdown for line switching. The worst performance comprised of (1) overtime and (2) inventory turnover, as shown in Figure 3. This finding reveals the actual situation in Taiwan's manufacturing industry, where manufacturers can effectively reduce the cost of workforce and operations, flexibly adjust the allocation of production operations, and achieve high efficiency in mold and line switch. However, they still rely on stockpiling as the solution for their inventory management due to insufficient resources, and overtime issues cannot be improved due to the loss of the manufacturing population.



Note: 1. Cost, 2. New product, 3. Quality, 4. Flexibility, 5. Delivery time, 6. Overtime, 7. Inventory turnover, 8. Lead time, and 9. Shutdown for line switching

**Figure 3 Performance of Lean Promotion**



Note: 1. Cost, 2. New product, 3. Quality, 4. Flexibility, 5. Delivery time, 6. Overtime, 7. Inventory turnover, 8. Lead time, and 9. Shutdown for line switching

**Figure 4 Performance of Lean Promotion by Enterprises of Various Sizes**

In addition to the continuous promotion of lean improvement, the 18 enterprises who participated in this study also identified (1) workplace revitalization activities, (2) early improvement, and (3) green lean management as their top three future priorities.

**Table 5. Survey and Statistical Table of Lean Projects for Future Promotion by Organizations**

Lean activity	Future promotion
(1) Workplace revitalization activities	8
(2) Workplace maintenance	4

(3) Operation improvement	4
(4) Logistics improvement	4
(5) Equipment improvement	4
(6) Quality improvement	5
(7) Early improvement: Business activities for producing new products	9
(8) Green lean management	7

## 5. CONCLUSIONS

This study's findings show supplier integration must be further reinforced in industry lean maturity. This is also reflected by the fact that most of Taiwan's enterprises are small- and medium-sized. In Taiwan, an enterprise is considered large if it has over 200 employees. However, from a global organizational scale perspective, such a size is still deemed small to medium in many other countries. Furthermore, it is challenging for small- and medium-sized enterprises to integrate suppliers. The sound performance in the customer dimension can be attributed to Taiwan's long-cultivated ability to survive in the midst of international challenges. High customization levels, small volume, and a wide variety of products and services have become requirements for improving national industrial competitiveness. In promoting lean activities, overtime and inventory turnover had the lowest scores. This finding corresponds to the current practice of inventory stockpiling due to manufacturing recruitment challenges and rising costs. This study provides a preliminary understanding of maturity in lean manufacturing promotion within industry through questionnaires and interviews. The questionnaires used in this study can be implemented in future evaluations by industry stakeholders. Regarding the continual promotion of lean activities in the future, the survey revealed that early improvements conducted when new products are developed are what most concerned enterprises. As such, these comprised the activities enterprises were most willing to invest in, accounting for 50%. Moreover, regarding workplace revitalization activities, the enterprises' willingness to invest in continuous improvement activities (QCC, QIT, and Six Sigma), the design of multi-functional systems, and the Karakuri Kaizen proposal ranked second. Enterprises have also begun to pay attention to their investment in green lean management activities to address sustainability issues, such as the importance of achieving net-zero carbon emissions.

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