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Priorities of Critical Success Factors for Lean Production Implementation of China's Factories

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Abstract: As demonstrated by the existing literature, lean production and management can contribute to the improvement of firm performance. However, there are many companies that struggle to apply its ethos and practices. The key point is that lean production differs from traditional mass production in many ways. Other than that, numerous studies have shown that business management systems must take into account both soft power and hard power. The main purpose of this study is to use the Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) tools to find out the soft and hard power factors, rank their importance in identifying the key success factors for the introduction of a lean production system, and assist in making the company's transformation smoother and more successful. The research results verify that a lean production system needs to take into account both soft power and hard power. Lean management in this study concludes the following priorities of critical factors: In hard power (technical dimension): (1) 5S, (2) seven major wastes, (3) solutions to lean production-related issues, (4) storage location management and warehouse management, (5) single minute exchange of die, and (6) total productive maintenance; In soft power (management dimension): (1) teamwork, (2) communication, (3) leadership, (4) culture, (5) initiative, and (6) employee training. The combination of soft power and hard power can improve the success rate of lean management system introduction.

Keywords: lean management; lean production; management functions; critical success factor; key success factor

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1. Introduction

Small- and medium-sized enterprises (SMEs) are pivotal to each country's economy [1]. However, SMEs, unlike large enterprises that boast complete resources, often grapple with resource constraints. Therefore, this study expects to help these SMEs improve firm performance and constitution through the lean production system (LPS) that has been proven by relevant studies to be conducive to improving firm performance.

Many tools used in LPS have been organized in the existing literature [2–6]. While many studies and books have introduced key tools for LPS, they have failed to identify the priorities of these tools when it comes to their implementation, hindering enterprises from introducing LPS. Additionally, recent studies have shifted their focus to the exploration of non-technical factors [7–11]. However, similar to challenges in hard power, a lack of priority suggestions has caused SMEs to abandon the effective LPS management system when they encounter roadblocks at the initial phase of the introduction of the LPS system.

Upon review of relevant studies, no studies have been identified concerning the priorities of success factors in the implementation of LPS. Upon review of relevant studies, no studies have been identified concerning the priorities of success factors in the introduction and implementation of LPS. Therefore, this study aims to identify the priorities of these critical factors. Methodologically, in this study, the analytic hierarchy process (AHP) and analytic network process (ANP) methods were used to determine the significant rankings of these critical success factors.

In addition to the research conclusions, the last part provides future research directions so that more researchers can develop issues for subsequent thinking.

2. Background

According to [12], follow [13] stated that less than 10% of UK organizations accomplish successful LPS implementations, while [14] indicated that, in a broader context, the index of successful changes into a lean organization barely achieves 20%. In fact, [15] argued that many Western companies unsuccessfully tried to import Toyota Production System (TPS) techniques into their production systems, neglecting the importance of the underlying sociocultural factors in the shift from a traditional mass-production model to LPS.

Why such a good management model has such a high failure rate is the motivation of this study. Therefore, the author discussed the success factors of the introduction of lean production and conducted a literature review distinguishing between hard power (technical dimension) and soft power (management dimension).

2.1. Hard Power (Technical Dimension)

According to the review [3], implementing lean practices can significantly improve the operational performance of SMEs and bring such benefits as waste reduction, efficiency enhancement, and customer satisfaction improvement. However, as indicated by the literature, despite the potential positive outcomes of lean practices for SMEs, there are numerous obstacles to overcome. Instilling a new culture may pose a major challenge to SMEs, with an emphasis on shared values, language, and behavior. The combination of the two becomes the main purpose of the research.

Market competition and environment dynamism drive enterprises to focus on the implementation of an effective improvement plan to meet the market that is small, diverse, and has short delivery times to meet the ever-changing customer demands. Currently, there is a growing trend of addressing such challenges using lean methods [6].

In order to respond to the global shift toward low-volume, diverse, and short lead-time market demands, a model that departs from the conventional mass-production model has emerged, which particularly highlights LPS. The primary purpose of adopting LPS is to eliminate waste and non-value-added activities. The goal is to develop a streamlined, high-quality system, thereby improving operational performance and cultivating a competitive edge [5].

Over the past few decades, numerous articles focusing on the description and characterization of LPS have been published in scientific journals. However, a precise and consistent method for defining or measuring LPS has yet to be developed. Nevertheless, researchers have commonly agreed on some overlapping practices [16]. Therefore, this study followed suit, using critical factors that reappear more than twice in the relevant literature as the questions of the questionnaires.

In order to measure the implementation of lean practices, the survey included methods for lean practice [7,17]. Moreover, in this study, an important technical approach to LPS summarized in previous studies was used to guide the design of questions of the questionnaires.

While a wealth of the literature has organized the fundamental principles and tools concerning LPS, there is a lack of priority references for SMEs in implementation when they introduce LPS. This is the reason why a lot of SMEs have failed in the LPS introduction.

Ref. [2] identified certain success factors practically applied in implementing lean manufacturing in the production process. Therefore, regarding various key technical methods for LPS, the literature was used as a standard benchmark in the technical dimension.

Based on the above literature review, this study organized critical factors that reappear in the literature more than twice in the technical dimension and designed the questionnaire based on these factors, as shown in Table 1.

Table 1. Major items in the questionnaire on the importance of key technical factors (compiled by this study).

Question Number	Topic	Journal 1	Journal 2	Journal 3	Journal 4	Journal 5	Journal 6	
Journal	IMPLEMENTATION OF LEAN MANUFACTURING IN PRODUCTION PROCESSES	Effects of HRM practices, lean production practices and lean duration on performance	Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies	Implementing lean practices in manufacturing SMEs: testing 'critical success factors' using Necessary Condition Analysis	Enabling the twin transitions: Digital technologies support environmental sustainability through lean principles	Exploring the Challenges and the Implementation of Lean Practices under Lean Transformation Project in Malaysian Small and Medium Enterprises	Importance of first-line employees in lean implementation in SMEs: a systematic literature review	Select as important factor
1	Visual management and anti-fool measures				v		v	※
2	The U-shaped line is separated from standing work and moving			v		v		※
3	IE action research and production line balancing							
4	Quick line change		v		v		v	※
5	Seven wastes	v	v		v	v	v	※
6	Fewer people and small batch production							
7	Storage management and warehousing management	v					v	※
8	5S				v	v		※
9	Continuous improvement				v			
10	Lean problem solving methods	v	v	v			v	※
11	Kanban management		v		v			
12	VSM value stream				v	v		※
13	supplier			v				
14	Preventive maintenance (TPM)	v	v					※
15	Pull system production			v			v	※

Note: "v" means that the journal has relevant management issues on the left. "※" Key elements that appear twice or more in the document.

2.2. Soft Power (Management Dimension)

While the findings of the existing literature suggest the crucial role of relevant factors in the implementation of lean practices by enterprises [17], they are not fully applied in the introduction of the LPS system. This hinders SMEs from maximizing the role of the LPS system.

Lean manufacturing has evolved from the Toyota Production System (TPS) put forward by Toyota Motor Corporation. Despite the generalization of the lean concept to various types of businesses, including service [18], a lot of companies failed when practicing this concept [19–21]. Ref. [22] recently demonstrated that few companies can effectively apply the lean concept like Toyota and reap benefits. Successful implementation of lean practices requires more than the improvement of tools and the application of techniques. Therefore, based on research [8], we reviewed the literature and reported that tool-oriented thinking with less attention to soft practice is prevalent and often governs lean healthcare implementation. This conclusion is invaluable, but unfortunately, it fails to provide insights into the way to combine soft power (management dimension) and hard power (technical dimension) and apply them in a complementary manner in the introduction of LPS.

According to the third contribution of the [11] study, the application of common soft lean practices in the lean system can both positively and negatively influence firm performance. The results of this study suggest that soft lean practices, such as delegation of authority to employees, visualization, or performance measurement, can contribute to the effectiveness of lean initiatives. In contrast, practices such as work standardization and goal setting may have adverse effects. This finding has challenged the traditional idea that work standardization and goal setting are deemed crucial to an organization's operations. Therefore, the shift toward negative effects underscores the significance of soft power (management dimension).

A number of studies that focus on "hard power" lean practice methods have been criticized because they failed to fully elaborate on the potential "success" or "failure" of the adoption of the lean system. Therefore, other studies deem that "soft power" lean practices are undoubtedly among the most critical factors in the successful implementation of the lean system by an organization [23,24]. Compared to "hard" lean practices, "soft" lean practices center on people and relationships. This includes the participation of front-line employees in addressing and continuously improving the group's problems, fostering partnerships with suppliers, the involvement of customers, and leadership [23,25] as cited in [10]. While the findings of these studies are promising, their value will be enhanced if they precisely locate the key priorities that SMEs can reference when implementing the LPS.

The research results reveal that implementing LPS is driven by several factors and that the key is improving customer satisfaction, efficiency, and delivery and reducing the costs in the process. Additionally, major soft lean practices identified include continuous cultural improvement, employee participation, employee training, and personnel development [9]. While essential motivating factors were summarized, these studies have failed to highlight the priorities. This is one of the driving forces behind this study, which aims to fill this gap.

Regarding soft power, in this study, knowledge leadership can be defined as a social influence process that aims to develop practical knowledge and stimulate and promote knowledge creation, sharing, and application by creating learning communities, driving knowledge flow, and forming networks. Playing these roles requires skills, such as translating learning experience into knowledge to cultivate a competitive edge and guiding and encouraging the culture of knowledge transfer and sharing [11]. However, the challenge lies in how this crucial knowledge leadership can be applied in the introduction of LPS. This requires guiding team members to embrace new knowledge so that they will not resist or prevent the organization's transformation.

Upon an extensive literature review with a focus on supply chain management from the environmental, social, and corporate governance perspective, this study identified critical factors in this regard, including compliance with environmental standards, safety and health priorities, commitment and support from the senior management, a sustainable governance structure, and clear and sustainable practice tracking [26]. Additionally, this study focuses on how to integrate the critical factors in supply chain management into the internal leadership of the organization.

As cited in [7], proposed 14 success factors in the implementation of lean activities by SMEs in the manufacturing industry. These factors are presented as follows: (1) support from the senior management, (2) a shared vision for improvement, (3) effective communication, (4) leadership, (5) human resources, (6) prioritizing learning, (7) adequate resources, (8) improvement-training, (9) the performance appraisal system, (10) supplier relationship, (11) customer relationship, (12) initiative, (13) team collaboration, and (14) organizational (management) culture. Covering major management issues related to the implementation of LPS, this study was used as a standard benchmark in the management dimension of this study.

Based on the review of literature in the management dimension above, critical factors that reappear more than twice were organized and used as the content of the questionnaire, as presented in Table 2.

Table 2. The main items of the questionnaire on the importance of key factors in management (compiled by this study).

Question Number	Topic	Journal 1	Journal 2	Journal 3	Journal 4	Journal 5	Journal 6	
Journal	Implementing lean practices in manufacturing SMEs: testing 'critical success factors' using Necessary Condition Analysis	Relationships between leadership and culture, human resources and process improvement in lean healthcare	The role of management in lean implementation: evidence from the pharmaceutical industry	Lean and action learning: towards an integrated theory?	Lean and its impact on sustainability performance in service companies: results from a pilot study	A Systematic Review and Synthesis of Empirical Research on "Knowledge Leadership": A New Insight in the Field of Knowledge Management	Analysing the critical success factors for implementation of sustainable supply chain management: an Indian case study	Select as important factor
1	Top management support	v		v	v		v	※
2	Shared vision for improvement		v	v		v		※
3	Good communication					v	v	※
4	Leadership	v	v	v	v	v		※
5	Human Resources	v	v					※
6	Focus on learning			v		v		※
7	Sufficient resources			v				
8	Improvement-Training	v	v	v	v			※
9	Performance evaluation system	v	v			v		※
10	Supplier link				v		v	※
11	Customer link							
12	Initiative		v		v	v		※
13	Teamwork	v	v	v		v		※
14	Organizational (Management) Culture	v			v	v		※

Note: "v" means that the journal has relevant management issues on the left. "※" Key elements that appear twice or more in the document.

Based on the above literature on soft power and hard power, some scholars have conducted research on key factors, but none has sorted out the combination and sequence of the two. This is also the source of motivation for this study.

3. Research Method

Research steps:
As shown in Figure 1.

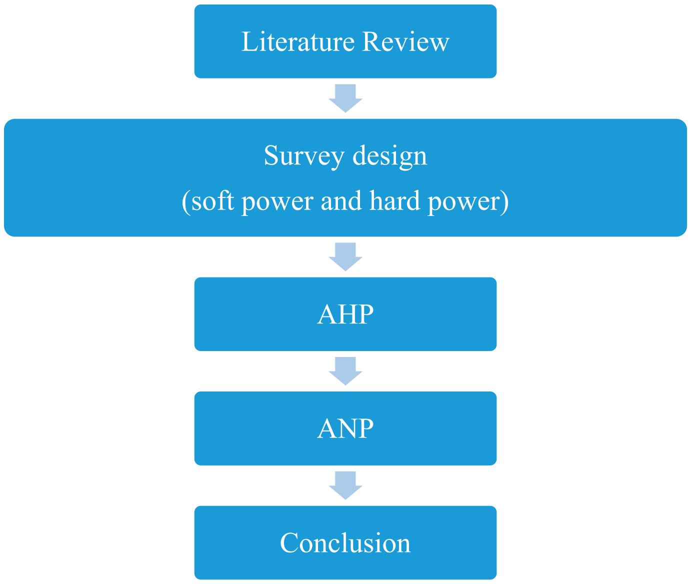

Figure 1. Research steps flow chart (compiled by this study).

Concerning the research method, in this study, questionnaires were designed based on literature reviews and using the Likert five-point scale. Then, the top six selected options in the questionnaires returned were subject to data analysis. More specifically, the SPSS software was employed to validate the reliability and validity of the questionnaires, and the AHP and ANP methods were used to assess sample consistency. By identifying the priorities of key success factors in the introduction of LPS by enterprises, this study will not only assist SMEs that are about to embrace LPS in improving their hard power but also make them realize the importance of soft power. Consequently, enterprises can quickly identify the right orientation and allocate resources more effectively.

3.1. AHP

AHP, an analytic method put forward by Professor Saaty at the University of Pittsburgh in 1971 [27], is mainly used to address complex decision-making issues that involve multiple criteria [28].

In this study section, the focus was given to the application of this method instead of the explanation of its framework.

The AHP method assists enterprises in making decisions featuring interrelated and frequently competing criteria and prioritizing these decision-making criteria within the context of the decision-making goals [29].

This method uses the concept of the network hierarchy and the comparison of matrix importance and weight to analyze the priority of each main dimension and sub-dimension (according to Saaty, to minimize errors, a single-level item should be within 7). Finally, the consistent ratios (C.R.) of the matrices are checked to reduce the likelihood of errors and provide scientific selection criteria for decision-making.

3.2. ANP

The ANP method [28], developed based on the AHP method and incorporating the dependence and feedback mechanisms, replaces the hierarchy perspective with the network perspective. The ANP method allows the obtainment and prediction of the internal relationships among all criteria, goals, and programs through the ratio scale. By calculating the limiting influence between control criteria, a super-matrix is formed to represent the strength of relevance between elements. This allows the simultaneous assessment of the outer and inner dependence of the group, thereby facilitating optimal decision-making [30].

The hierarchical analysis process in this study is as follows:

1. The key topic was decomposed into the main dimensions and sub-dimensions based on the literature review, and then a hierarchical structure of complex issues was established to analyze and specify the issues.

2. Pairwise matrices were created to compare the relative importance of each major and minor dimension. These pairwise comparisons were typically based on a nine-point scale [27], as shown in Table 3.

Table 3. Significance and description of AHP scale assessment.

Evaluation Scale	Definition	Description
1	Equally important	Equal intensity: the contribution of both factors is equally important.
3	One is less important relative to the other	Slightly stronger: empirical Judgment is slightly biased towards a certain element.
5	Basic or strong importance	Fairly strong: empirical judgment strongly favors a certain element.
7	Very important	Very strong: empirical judgment strongly favors a certain element.
9	Absolutely important	Absolute inclination toward certain element.
2, 4, 6, 8	The median value of two adjacent judgments	Its somewhere in between.
reciprocal of previous value	If the factor "I" has one of the previously mentioned numbers as compared to the value factor "j," then j has the reciprocal as compared to i.	
Sources: [31]		

3. According to [32], it is necessary to calculate the C.R. As decision-making involves pairwise comparisons, it is challenging to achieve perfect consistency. Therefore, a consistency test is necessary in order to form a consistency index (C.I.). When C.I. = 0, it indicates perfect consistency between judgments; when it > 0, it suggests inconsistency between judgments. Saaty recommended C.I. $\leq$ 0.1, indicating acceptable bias.

The C.R. of the AHP is calculated as follows:

3.1 First, the C.I. was calculated using Equation (1). If C.I. $\leq$ 0.1, it indicates the degree of consistency is satisfactory.

$$\text{C.I.} = (\lambda\text{max} - \text{n})/(\text{n} - 1) \tag{1}$$

3.2 The table was consulted to calculate the random index (R.I.)

The consistency index obtained from a randomly generated positive-reciprocal matrix is referred to as R.I. Its value tends to increase with the matrix order n. Table 4 displays the R.I. values of the positive-reciprocal matrix in each order calculated by Saaty. The R.I. values for matrix orders 1 to 11 were calculated based on a sample size of 500, while values for matrix orders 12 to 15 were calculated based on a sample size of 100.

Table 4. Stochastic indicators correspond to the positive and inverted value matrix in each order.

Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

Sources: [27].

In this study, the matrix order is 3. According to the table, the R.I. value is 0.58. C.R. = C.I./R.I.

4. The Excel software was repeatedly employed to calculate the weight of each main dimension and sub-dimension and organize the results in order of importance.

The AHP method involves the following steps, as shown in Figure 2: Structuring the evaluation of complex issues and establishing a hierarchical structure; setting an evaluation scale for each issue and establishing pairwise comparison matrices; calculating eigenvalues and eigenvectors; testing consistency; selecting the data that passes the consistency test for calculating the weight at each level and the overall level, and ultimately determining the priorities of various elements or programs.

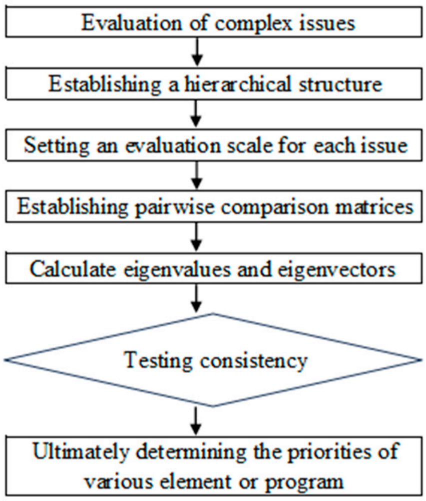

Figure 2. Hierarchical analysis execution process Sources: [33].

3.3. Sample and Data Collection

In this study, five enterprises across sectors that had implemented LPS for more than three years were selected for an empirical study.

The five enterprises selected as the samples of this study used to operate using a mass-production model. However, due to a shift toward "low-volume, diverse, and short lead-time" market demands in recent years, mass production can no longer meet the customer and market demands. This has placed enterprises under extreme pressure for transformation. With the introduction of LPS, these enterprises have maximized the efficiency of their resources. Additionally, the transformation has doubled its operational performance.

Introduction to five case companies: as shown in Table 5.

Table 5. Case companies to be investigated in the questionnaire (compiled by this study).

Number	Main Products of the Industry	Listed on the OTC Market	Factory Location	Scale
1	Connector manufacturer in Taiwan	Over-the-Counter Company in Taiwan	Shenzhen, China	4000 employees
2	Computer manufacturer in Taiwan	Over-the-Counter Company in Taiwan	Wujiang, China	1700 employees
3	Mobile phone case manufacturer in Taiwan	Over-the-Counter Company in Taiwan	Kunshan, China	2200 employees
4	Oil seal manufacturer in Taiwan	N	Jiangxi, China	700 employees
5	Screw manufacturer in Taiwan	N	Suzhou, China	1300 employees

Case 1: Taiwanese connector manufacturer (Taiwan OTC company, setting up factory in Shenzhen, Mainland China)

1. Successful case: The president of this company was unable to improve the company's operations. He is anxious to hope that the company can turn around quickly. The top executive will personally lead the improvement. The improvement is very effective, so he chose this company as the subject of the investigation.

2. Main results:

2.1 Saving area of warehouse inventory: Purchase goods in batches; the original warehouse use area is 4500 square meters; after the improvement, it only takes 2100 square meters; and the warehouse utilization rate is only 47.7% (saving storage space).

2.2 Saving of carrying distance: After adjusting the walking distance in the nine-square grid pattern, the walking distance is reduced by 61901M.

2.3 Shipping is finally on time:

2.4 Reducing the number of staff: Taking the staffing of Section 4 of the Planning Department as an example, it was reduced from the original 34 people to the current 26 people.

The annual salary costs are reduced by approximately NTD 1.44 million.

2.5 The team atmosphere has changed from linear production lines to U-shaped production lines. People no longer work on isolated islands and cooperate with each other.

Case 2: Taiwanese LED manufacturer (Taiwan OTC company, setting up factory in Wujiang, Mainland China)

1. Successful cases: The company has a leading position in the field of optics. In addition to the development of LED products, it also develops towards the art of light sculpture. It has worked in Olympic venues such as the Bird's Nest and Water Cube in mainland China; however, organizational development remains the same. We hit a threshold, so we introduced lean production and achieved good results.

2. Main results:

2.1 Cross-departmental incoordination and fragmentation, supplemented by teamwork and the concept of the VSM Independent Research Society, change the team consciousness.

2.2 Quality problems cannot be found from the root cause and problems recur; introduce the Why-Why analysis method to eliminate them. Use experience to judge, find the root cause, and take corrective measures to prevent recurrence.

2.3 The production process fails to balance the production line, resulting in waiting and waste; introduce bottleneck station analysis to perform line balancing. Rearrange the production process to improve unnecessary waste and accumulation.

Overall performance: The delivery time was shortened from the original 45 days after receiving the order to 20 days after receiving the order; the yield rate has increased from the original 80% to 92%.

Case 3: Taiwanese mobile phone casing manufacturer (Taiwan OTC company, setting up factory in Kunshan, Mainland China)

1. Successful case: This company is in the traditional injection industry, and the market demand has shifted from large batches to small batches. In the past, due to traditional concepts, customers made products early even if they did not need them, resulting in a waste of inventory and costs. Therefore, lean production was introduced. Rapid mold change has greatly changed the overall operation method.

2. Main results:

2.1 Learn the Single Minute Exchange of Die (SMED) of lean management to quickly change molds. The mold change time can be greatly reduced from the original 1.5 h to less than 20 min so that you can accept small and diverse orders.

2.2 In the past, the lack of ability to quickly change molds led to wrong decisions. The team was required to produce without orders as long as there was excess production capacity. From then on, this phenomenon no longer occurred, and a lot of inventory and losses were reduced.

Overall performance: actual revenue achievement rate was 130%, operating gross profit was 159%, and customer complaints were reduced from 5% to 3%.

Case 4: Taiwanese oil seal manufacturer (Taiwan's leading oil seal manufacturer, setting up factory in Jiangxi, Mainland China)

1. Successful cases: The company was established for more than 36 years. In the first 15 years, the company focused on professional manufacturing and mold development. Now it is more committed to the design and development of various seals and can provide customized seals according to customer needs and chemical product specifications. In order to meet the requirements of various automobile industry customers, in addition to being certified by the IATF 16949 quality management system, it also actively introduces crystal management to allow more potential customers to successfully pass the factory inspection.

2. Main results:

2.1 Based on 5S, we improve the on-site environment on a large scale and win unanimous praise from customers.

2.2 The company has successively obtained patents for rotating oil seals and Taiwan Excellence Awards.

2.3 Expand Taiwan's successful experience in setting up factories in Jiangxi, mainland China, to avoid many mistakes in copying costs.

Case 5: Taiwan's top three screw manufacturers set up second overseas factories in Suzhou, China, and the Philippines.

1. Successful case: This company occupies a place in the screw industry. Due to the hot forging at the first stage of the process, the mold change must take three days, resulting in a lot of waiting and waste of resources. After the introduction of lean production, the waiting and waiting time for the project was greatly improved. Fast delivery.

2. Main results:

2.1 The mold change time of the first hot forging process was significantly reduced from 3 days to 1 day.

2.2 The wasted ineffective working hours were significantly reduced by 80%.

2.3 Inventory Due to the improvement of quick mold change, there is no need to worry about overproduction caused by delays in mold change, and the inventory amount is reduced by 50%.

2.4 Copy Taiwan's successful experience in introducing lean production to the second factory in Suzhou, Philippines, to improve the overall operating performance of the group.

A total of 80 questionnaires were distributed to the five high-quality enterprises. Of them, 73 were returned, achieving a response rate of 91.25%. The survey covered a variety of respondents, as shown in Table 6, including general employees and grassroots-level, middle-level, and senior executives. Of these respondents, 65% are males and 35% are females. Respondents were required to have a minimum of one year of practical experience in LPS (Please refer to the Appendix A for relevant questionnaires).

Table 6. Background information of respondents (compiled by this study).

Gender	Number Persons	Seniority	Number Persons	Posts	Number Persons
Male	48	1–3 years	11	General Employees	25
Female	25	4-6 years	38	Grassroots cadres	22
		7–9 years	20	Mid-level cadres	18
		More than 9 years	4	Senior	8

Results of questionnaires returned:

The questionnaires were designed in a way that allowed respondents to choose multiple options, and the statistics on the respondents' answers are presented below Tables 7 and 8:

Table 7. The top six items of technical priority (compiled by this study).

Items	Seven Wastes	5S	Lean Problem-Solving	Quick Changeovers	Preventive Maintenance (TPM)	Storage Location Management and Warehouse Management
Number of votes	32	30	28	27	26	25

Table 8. The top six items of management plane priority (compiled by this study).

Items	Communicate	Leadership	Teamwork	Initiative	Culture	Employee Training
Number of votes	39	37	36	34	31	30

3.4. Reliability and Validity Analysis

Based on the data from the questionnaires returned, the reliability and validity analyses were conducted using the SPSS 29.0 software in the technical and management dimensions.

(1) Reliability analysis

In this study, the Cronbach's α values of the questionnaires for the technical and management dimensions were 0.896 and 0.951, respectively. Therefore, the α value of the reliability analysis in this study > 0.70, indicating that the questions in the questionnaires are highly reliable and thus the questionnaires are acceptable (the results of the reliability analyses are presented in Tables 9 and 10 below).

Table 9. Reliability analysis of technical questionnaires (compiled by this study).

Reliability Statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
0.896	0.897	10

Table 10. Reliability analysis of management questionnaires (compiled by this study).

Reliability Statistics		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Items**
0.949	0.951	10

(2) Validity analysis

According to Kaiser, when the Kaiser–Meyer–Olkin (KMO) value < 0.5, factor analysis is deemed inappropriate. In this study, the KMO values of the questionnaire analyses were >0.5. Additionally, according to the result of Bartlett's Test of Sphericity, each dimension is of significance (<0.05). Therefore, the questionnaires in this study are valid and hold a reference value (the results of the validity analyses are presented in Tables 11 and 12).

Table 11. Validity analysis of the technical questionnaire (compiled by this study).

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.737
Bartlett's Test of Sphericity	Approx. Chi-Square	865.344
	df	45
	Sig.	<0.001

Table 12. Analysis of the validity of the management questionnaire (compiled by this study).

KMO and Bartlett's Test		
Kaiser–Meyer–Olkin Measure of Sampling Adequacy.		0.695
Bartlett's Test of Sphericity	Approx. Chi-Square	977.893
	df	45
	Sig.	<0.001

3.5. Data Analysis

In order to comply with the AHP requirement that the hierarchy should consist of no more than seven factors, of the results of the previously administered questionnaires designed using the Likert five-point scale, the top six selected options were selected for an AHP analysis by senior executives invited, as shown in Tables 13 and 14. This aims to identify critical factors and provide a reference for enterprises in the establishment of the management functions for the executives.

Table 13. Pairwise comparison matrix of key factors in AHP technology (compiled by this study).

	Seven Wastes	**5S**	**Lean Problem-Solving**	**Quick Changeovers**	**Total Preventive Maintenance (TPM)**	**Storage Location Management and Warehouse Management**
Seven wastes	1	3.17	3.96	3.49	4.11	5.3
5S	0.32	1	3.34	4.11	4.06	4.22
Lean problem-solving	0.32	0.3	1	4.61	3.4	4.67
Quick changeovers	0.32	0.3	0.22	1	2.35	3.21
Total Preventive maintenance (TPM)	0.32	0.3	0.22	0.43	1	4.71
Storage location management and warehouse management	0.32	0.3	0.22	0.43	0.21	1
Total	2.58	5.37	8.95	14.06	15.13	23.11

Table 14. Pairwise comparison matrix of key factors in AHP management (compiled by this study).

	Commu Nicate	**Leadership**	**Teamwork**	**Initiative**	**Culture**	**Employee Training**
Communicate	1	3.4	2.94	5.45	3.14	4.76
Leadership	0.29	1	3.56	5.24	3.84	5.11
Teamwork	0.29	0.28	1	5.45	3.4	4.78
Initiative	0.29	0.28	0.18	1	2.11	3.01
Culture	0.29	0.28	0.18	0.47	1	4.22
Employee training	0.29	0.28	0.18	0.47	0.24	1
Total	2.47	5.52	8.05	18.09	13.73	22.88

Step 1: Building an AHP structure diagram. as shown in Figure 3.

Step 2: Designing AHP questionnaires and selecting experts for the survey

The eight senior executives who participated in the survey designed using the five-point scale were selected as experts for the AHP analysis.

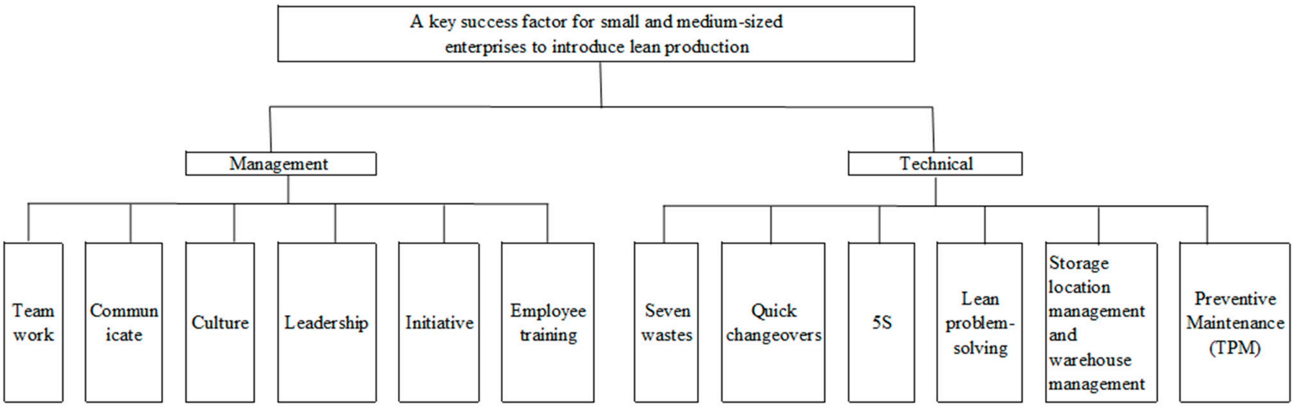

Figure 3. AHP architecture diagram (compiled by this study).

(1) AHP analysis in the technical dimension

The pairwise comparison results were tested for consistency. If the C.I. ≤ 0.1, the consistency will be deemed satisfactory, as shown in Table 15.

Table 15. AHP seeks the importance C.I. consistency of key factors in technical methods (compiled by this study).

Seven wastes	1.15	
5S	0.89	
Lean problem-solving	0.78	
Quick changeovers	0.93	
Preventive Maintenance (TPM)	0.95	
Storage location management and warehouse management	1.4	
Total	6.12	
Average	1.02	
Consistency metrics (consistency index, C.I.) C.I. = (λmax − n)/(n − 1)	0.0235	≤0.1 Stands for consistency OK
Consistency ratio (consistency ratio, C.R.) C.R. = C.I./R.I.	0.0235/0.58 = 0.0405	≤0.1 Stands for consistency OK

Upon an AHP analysis, the technical factors are prioritized in the following order: Seven major wastes, 5S, solutions to LPS-related issues, SMED, TPM, and storage location management and warehouse management, as presented in Table 16.

Table 16. AHP prioritizes key technical factors (compiled by this study).

		Eigenvectors
Key Factors	**Average**	**Precedence**
Seven wastes	0.36	1
5S	0.24	2
Lean problem-solving	0.17	3
Quick changeovers	0.09	4
Preventive Maintenance (TPM)	0.08	5
Storage location management and warehouse management	0.05	6

(2) AHP analysis in the management dimension

The pairwise comparison results were tested for consistency. If the C.I. ≤ 0.1, the consistency will be deemed satisfactory, as shown in Table 17.

Table 17. AHP is the consistency of the priority of key factors on the management plane eigenvalue.es/eigenvectors (compiled by this study).

Communicate	1.19	
Leadership	0.88	
Teamwork	0.76	
Initiative	0.93	
Culture	0.96	
Employee training	1.39	
Total	6.09	
Average	1.02	
Consistency metrics (consistency index, C.I.) C.I. = (λmax − n)/(n − 1)	0.018	≤0.1 Stands for consistency OK
Consistency ratio (consistency ratio, C.R.) C.R. = C.I./R.I.	(0.018/0.58 = 0.031)	≤0.1 Stands for consistency OK

Upon an AHP analysis, the management factors are prioritized in the following order:

Communication, leadership, teamwork, initiative, culture, and employee training, as presented in Table 18.

Table 18. AHP prioritizes key factors on the management plane (compiled by this study).

		Eigenvectors
Key Factors	**Average**	**Precedence**
Communicate	0.35	1
Leadership	0.26	2
Teamwork	0.18	3
Initiative	0.09	4
Culture	0.08	5
Employee training	0.05	6

Considering that the AHP method assumes that the relevant factors of an issue are independent of and do not influence each other, which does not exist in practice, the ANP method was used to analyze these factors again [30].

3.6. ANP Architecture Diagram

Step 1: Modeling and structuring the relationship as shown in Figures 4–7.

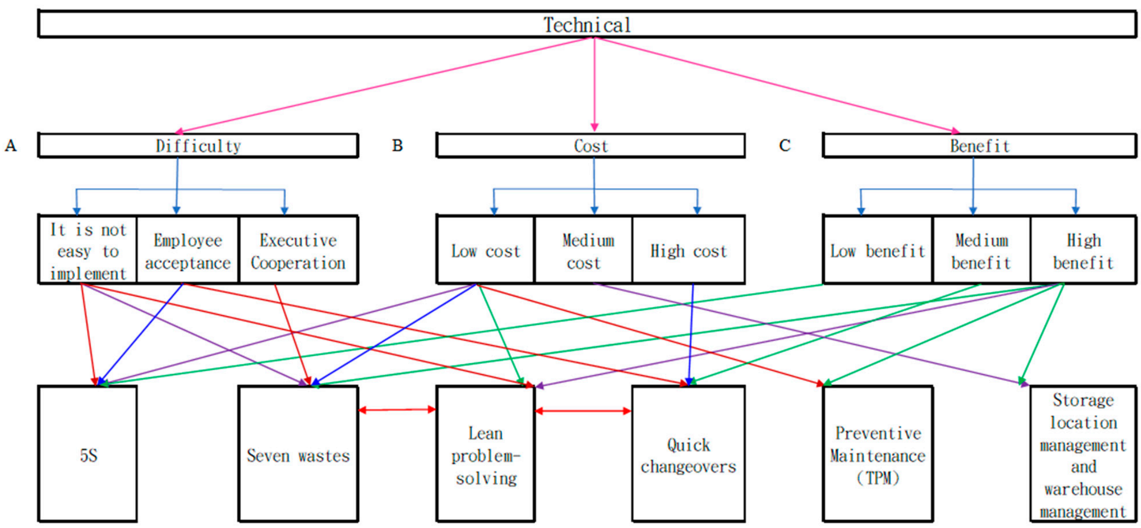

Figure 4. Technical ANP architecture diagram (compiled by this study).

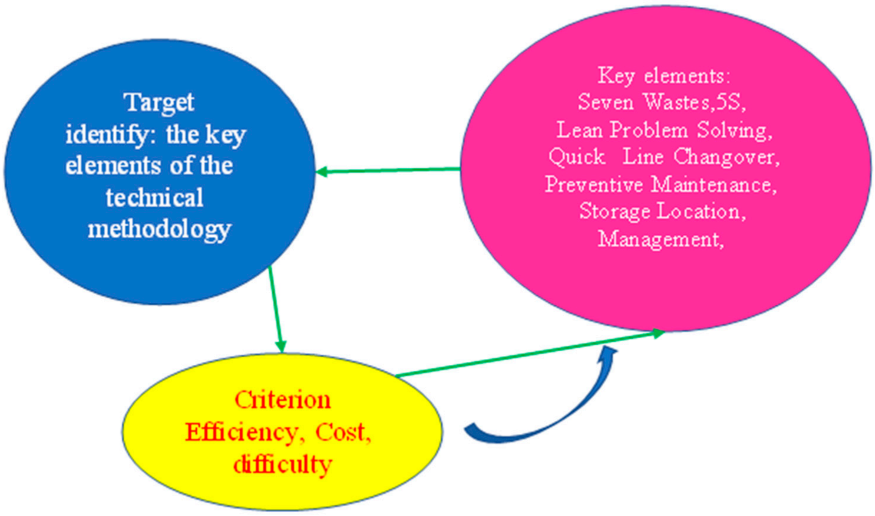

Figure 5. Priority network diagram of key elements of ANP technical plane (compiled by this study).

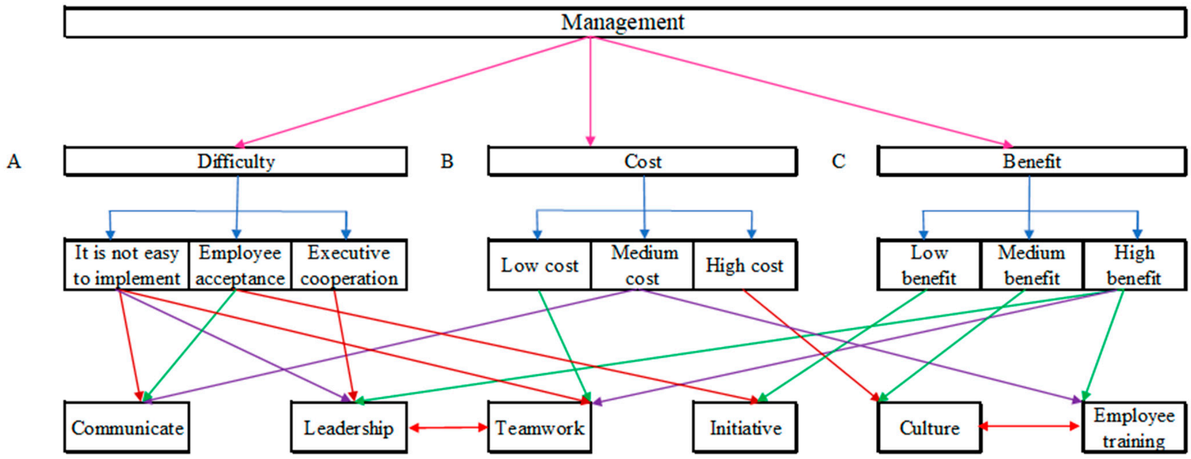

Figure 6. ANP architecture diagram of the management plane (compiled by this study).

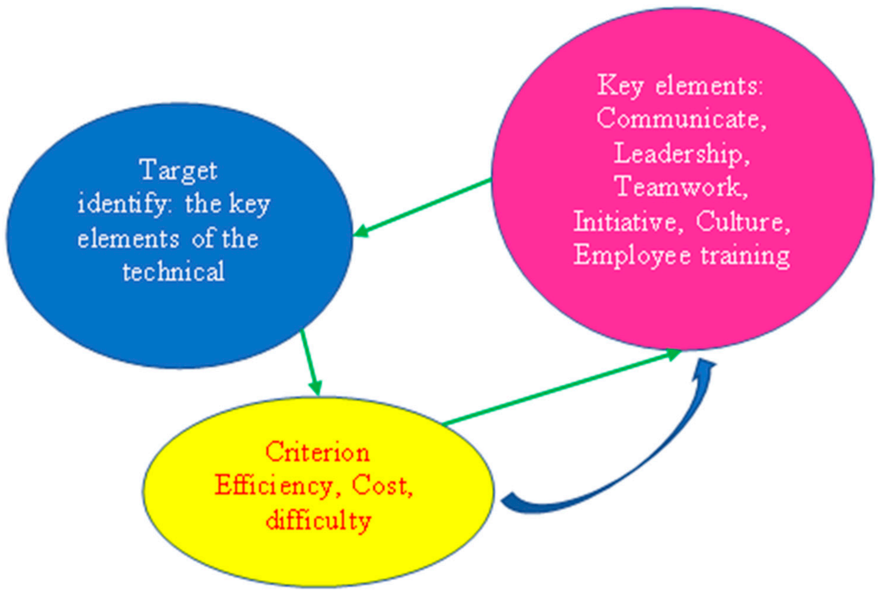

Figure 7. Priority network diagram of key elements of ANP management plane (compiled by this study).

Definitions in this study, as shown in Figure 5:

"Difficulty": A critical factor in the successful or unsuccessful introduction, categorized as a significant contributing factor.

"Benefit": A factor most influenced by other clusters, categorized as an outcome factor.

"Cost": An important evaluation factor, categorized as a central influence factor.

Definitions in this study, as shown in Figure 7:

"Difficulty": A critical factor in the successful or unsuccessful introduction, categorized as a significant contributing factor.

"Benefit": A factor most influenced by other clusters, categorized as an outcome factor.

"Cost": An important evaluation factor, categorized as a central influence factor.

In this study, the assessment criteria are defined as follows in Table 19:

Table 19. ANP assessment criteria and description (compiled by this study).

Criterion	**Description**	**Criterion**	**Description**
Difficulty		**Efficiency**	
It is not easy to implement	Whether the management functions of the management cadres are adequate	Low benefit	10% increase in the company's overall efficiency
Employee acceptance	Is it easy for employees to understand	Medium benefit	20% increase in the company's overall efficiency
Executive Cooperation	Motivation and willingness of senior executives	High benefit	30% increase in the company's overall efficiency
Criterion	Description		
Cost			
Low cost	The cost is less than NTD 100,000		
Medium cost	The cost is less than NTD 300,000		
High cost	The cost is less than NTD 500,000		

Step 2: Pairwise comparison matrix and priority vector

In the ANP and AHP methods, a pairwise comparison matrix is used to measure the relative importance of various elements to a certain criterion as follows in Figures 8 and 9.

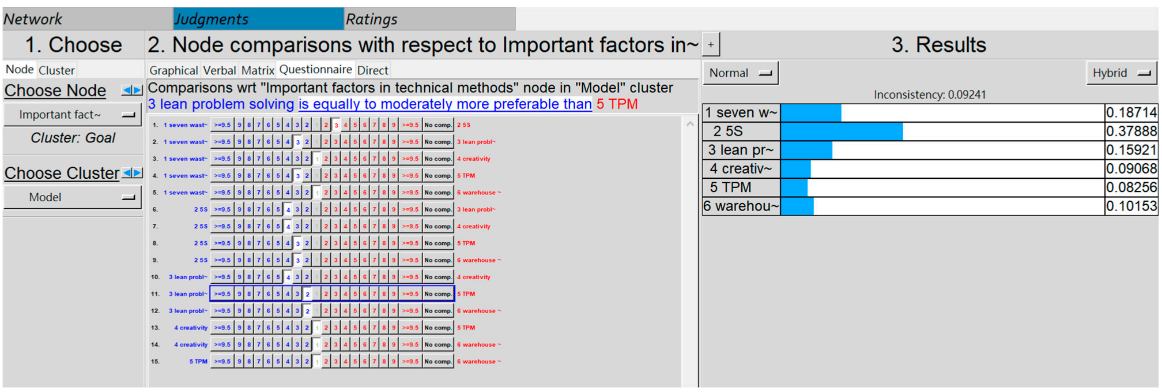

Figure 8. ANP technical key elements pairwise comparison matrix (compiled by this study).

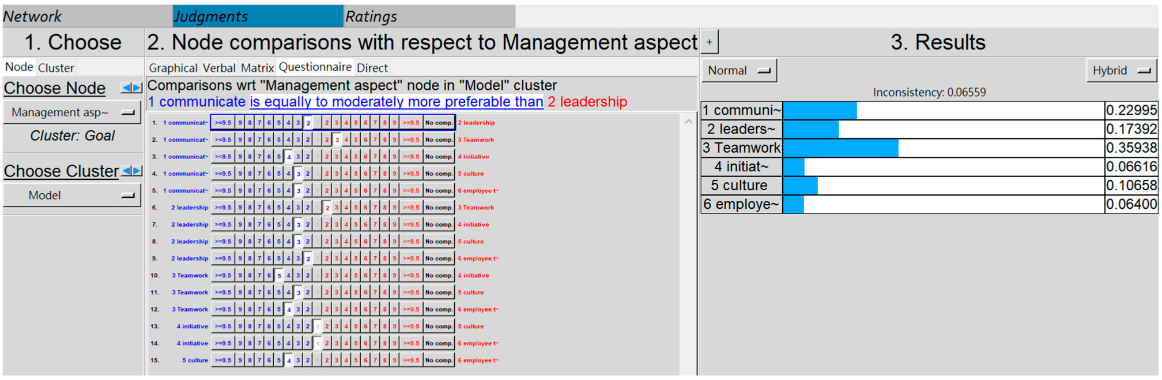

Figure 9. Pairwise comparison matrix of key elements of the ANP management plane (compiled by this study).

Step 3: Constructing a super-matrix

According to the [28] ANP method, the super-matrix is used to calculate the degree of interdependence as follows in Figures 10 and 11.

Clusters	Nodes	Important factors in technical methods	1 benefit	2 cost	3 Difficulty	1 seven wastes	2 5S	3 lean problem solving	4 creativity	5 TPM	6 wareho
Goal	Important factors in technical methods	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Key elements	1 benefit	0.163004	0.000000	0.000000	0.000000	0.333333	0.333333	0.614411	0.500000	0.000000	0.000000
	2 cost	0.168686	0.000000	0.000000	0.000000	0.333333	0.333333	0.117221	0.000000	0.000000	1.000000
	3 Difficulty	0.168310	0.000000	0.000000	0.000000	0.333333	0.333333	0.268369	0.500000	1.000000	0.000000
Model	1 seven wastes	0.091380	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2 5S	0.183000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3 lean problem solving	0.088760	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4 creativity	0.034018	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	5 TPM	0.036021	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	6 warehouse management	0.066821	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 10. ANP technical, critical elements super-matrix (compiled by this study).

Clusters	Nodes	Management aspect	1 benefit	2 cost	3 Difficulty	1 communicate	2 leadership	3 Teamwork	4 initiative	5 culture	6 employee training
Goal	Management aspect	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Key elements	1 benefit	0.194257	0.000000	0.000000	0.000000	0.333333	0.333333	0.614411	0.500000	0.000000	0.000000
	2 cost	0.120378	0.000000	0.000000	0.000000	0.333333	0.333333	0.117221	0.000000	0.000000	1.000000
	3 Difficulty	0.185366	0.000000	0.000000	0.000000	0.333333	0.333333	0.268369	0.500000	1.000000	0.000000
Model	1 communicate	0.114976	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	2 leadership	0.086960	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	3 Teamwork	0.179692	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	4 initiative	0.033080	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	5 culture	0.053290	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
	6 employee training	0.032002	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 11. ANP management plane key elements super matrix (compiled by this study).

Step 4: Selecting the optimal program

According to the score, choose the priority order of importance as follows in Figures 12–15.

Clusters	Nodes	Important factors in technical methods
Goal	Important factors in technical methods	0.000000
Key elements	1 benefit	0.163004
	2 cost	0.168686
	3 difficulty	0.168310
Model	1 seven wastes	0.091380
	2 5S	0.183000
	3 lean problem solving	0.088760
	4 creativity	0.034018
	5 TPM	0.036021
	6 warehouse management	0.066821

Figure 12. Priority of key elements of the ANP technical plane (compiled by this study).

Clusters	Nodes	Important factors in technical methods
Goal	Important factors in technical methods	0.000000
Key elements	1 benefit	0.194257
	2 cost	0.120378
	3 difficulty	0.185366
Model	1 communicate	0.114976
	2 leadership	0.086960
	3 teamwork	0.179692
	4 initiative	0.033080
	5 culture	0.053290
	6 employee training	0.032002

Figure 13. ANP management plane key element prioritization (compiled by this study).

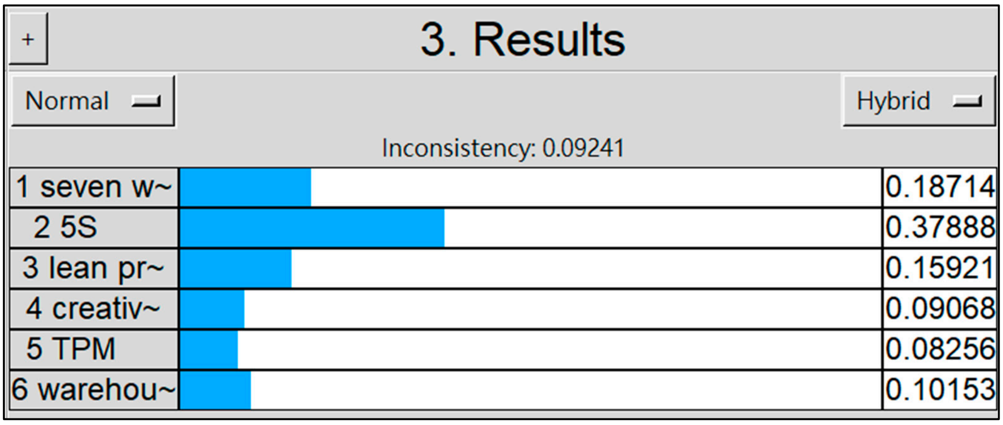

Figure 14. Non-conformance testing of key elements of ANP technical (compiled by this study).

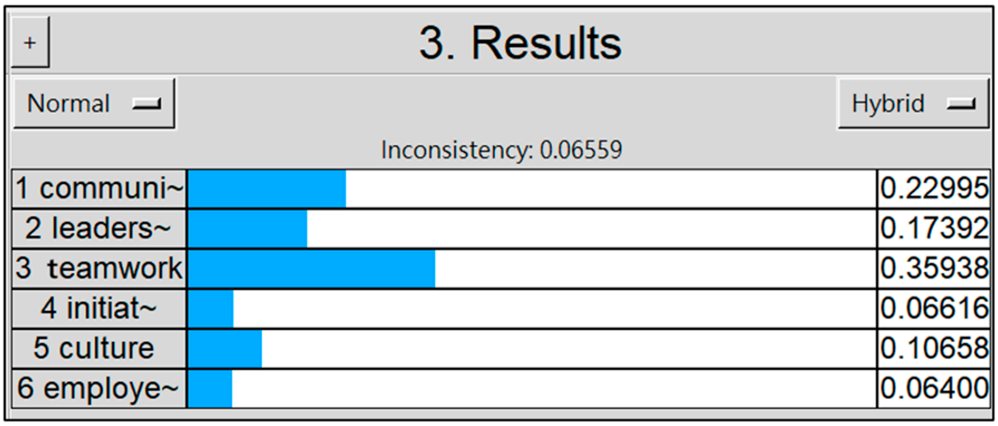

Figure 15. Non-conformance testing of key elements of the ANP management plane (compiled by this study).

Inconsistency test values:

The inconsistency test values for the technical and management dimensions are 0.09241 and 0.06559, respectively, both <0.1, signifying acceptable results.

4. Results

Concerning the priorities of critical factors in the technical and management dimensions, the results of the AHP and ANP analyses are compared below in Tables 20 and 21.

Table 20. Comparison of results between AHP and ANP methods for key technical factors. Technical critical success factors (compiled by this study).

	(AHP) Analytic Hierarchy Process		(ANP) Analytic Network Process	
1	Seven wastes	0.36	5S	0.18
2	5S	0.24	Seven wastes	0.091
3	Lean problem-solving	0.17	Lean problem-solving	0.088
4	Quick changeovers	0.09	Total Preventive Maintenance (TPM)	0.036
5	Total Preventive Maintenance (TPM)	0.08	Quick changeovers (creativity)	0.034
6	Storage location management and warehouse management	0.05	Storage location management and warehouse management	0.006

Table 21. Comparison of results between AHP and ANP methods for key management factors. Management critical success factors (compiled by this study).

	(AHP) Analytic Hierarchy Process		(ANP) Analytic Network Process	
1	Communicate	0.35	Teamwork	0.18
2	Leadership	0.26	Communicate	0.11
3	Teamwork	0.18	Leadership	0.09
4	Initiative	0.09	Culture	0.05
5	Culture	0.08	Initiative	0.033
6	Employee training	0.05	Employee training	0.032

As indicated by the results of the comparisons, there is a significant discrepancy between the AHP and ANP methods in the priority order of these factors, which is closer to the actual operations of enterprises. This discovery is very important.

5. Discussion

In order to verify whether technical and management are related, we used Poisson allocation to verify the correlation between the two factors.

Perform Pearson correlation analysis on the technical and management bivariate variables, and the analysis results are shown in Table 22.

Table 22. Pearson correlation (compiled by this study).

Relevance			
		Technical	Management
Technical	Pearson Relevance	1	1.000 **
	Significance (two-tailed)		9.49×10^{-9}
	N	3	3
Management	Pearson Relevance	1.000 **	1
	Significance (two-tailed)	9.49×10^{-9}	
	N	3	3

** Correlation is significant at the 0.01 level (two-tailed).

The significance is <0.01, and the two have a significant positive correlation [34], proving that soft power and hard power must be used at the same time, which can increase the success of the introduction of lean production.

Discussion of the results of this study proves that if an organization wants to introduce lean production, not just the technical aspect (hard power) can successfully introduce it successfully but must demonstrate various elements of the management aspect (soft power) in order to achieve good management and the system does its job.

Corresponding to the results of the study [9,35], managers are reminded that in order to improve a company's performance, in addition to strictly implementing hard and lean practices, they must also pay attention to soft and lean practices to achieve better results.

6. Conclusions

6.1. Theoretical Contributions

Based on a review of the literature on different topics but with a common focus on the exploration of critical success factors in the introduction of LPS, such as [7,10]. This study identifies six key factors in both technical and management dimensions, as discussed above. Additionally, these factors are prioritized through the AHP and ANP analyses. The biggest difference between the results of this study and other similar studies is the prioritization of critical success factors in technical and management dimensions in introducing LPS. By presenting the critical factors and their respective priorities for organizations to pay attention to when they intend to introduce LPS or carry out transformation, this study will help LPS enterprises maximize resource efficiency and accelerate the enhancement of operational performance.

6.2. Managerial Implications

During the practical operations of SMEs, the lack of a robust information network often results in the fragmented accumulation of knowledge communicated orally or recommended by consulting firms. However, the varying quality of guidance on LPS has caused SMEs to invest significant human and financial resources without achieving observable outcomes. In this study, the subjects come from SMEs that have successfully introduced LPS, and the reliability and validity of the questionnaires are also validated. The research findings can represent real-world scenarios. Therefore, this study can serve as a reference for enterprises seeking to introduce the LPS system in the future.

6.3. Limitations and Future Research Directions

This study is limited to manufacturing factories in mainland China, and it is not enough to represent that the research results are applicable to all industries and countries with different cultures.

The literature reviewed mainly focuses on the exploration of theories concerning LPS, leaving practical applications overlooked. Therefore, it is recommended that future studies delve into real-world practices in technical and management dimensions in order to propose feasible solutions. The ultimate goal is to disseminate the findings among enterprises, thereby assisting them in smoothly introducing the LPS system and fully realizing the value of the studies.

Author Contributions: Conceptualization, P.-Y.K. and R.-H.L.; methodology, P.-Y.K.; software, P.-Y.K.; validation, P.-Y.K. and R.-H.L.; investigation, P.-Y.K.; writing—original draft preparation, P.-Y.K.; writing—review and editing, P.-Y.K. and R.-H.L.; supervision, R.-H.L. All authors have read and agreed to the published version of the manuscript.

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Appendix A

Questionnaire on the importance of key technical priority and management plane priority on five equal scales.

Regarding the following tools and techniques commonly used in lean production, how important do you think each tool and technique is to the introduction of lean? (Compiled by this study).

Question Number	Topic	Insignificance 1	Slight 2	Important 3	Critical 4	Vital 5
1	Visual management and anti-fool measures					
2	The U-shaped line is separated from standing work and moving					
3	Quick line change					
4	Seven wastes					
5	Storage management and warehousing management					
6	5S					
7	Lean problem-solving methods					
8	Kanban management					
9	VSM value stream					
10	Preventive Maintenance (TPM)					
11	Pull system production					

Based on your practical experience, help to check the following questions on organizational management: Regarding the introduction of lean production in enterprises, how important do you think these issues are in management? (compiled by this study).

Question Number	Topic	Insignificance 1	Slight 2	Important 3	Critical 4	Vital 5
1	Top management support					
2	Shared vision for improvement					
3	Good communication					
4	Leadership					
5	Human Resources					
6	Focus on learning					
7	Improvement-Training					
8	Performance evaluation system					
9	Supplier link					
10	Initiative					
11	Teamwork					
12	Organizational Culture					

Conduct AHP analysis on technical aspects: (compiled by this study).

		Vital																Vital		
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
1	Seven wastes																		5S	2
1	Seven wastes																		Lean problem-solving	3
1	Seven wastes																		Quick changeovers	4
1	Seven wastes																		Total Preventive Maintenance (TPM)	5
1	Seven wastes																		Storage location management and warehouse management	6

2	5S	Lean problem-solving	3
2	5S	Quick changeovers	4
2	5S	Total Preventive Maintenance (TPM)	5
2	5S	Storage location management and warehouse management	6
3	Lean problem-solving	Quick changeovers	4
3	Lean problem-solving	Total Preventive Maintenance (TPM)	5
3	Lean problem-solving	Storage location management and warehouse management	6
4	Quick changeovers	Total Preventive Maintenance (TPM)	5
4	Quick changeovers	Storage location management and warehouse management	6
5	Total Preventive Maintenance (TPM)	Storage location management and warehouse management	6

Conduct AHP analysis on management aspects: (compiled by this study).

		Vital																Vital		
		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
1	Commu nicate																		Leadership	2
1	Commu nicate																		Teamwork	3
1	Commu nicate																		Initiative	4
1	Commu nicate																		Culture	5
1	Commu nicate																		Employee training	6
2	Leadership																		Teamwork	3
2	Leadership																		Initiative	4
2	Leadership																		Culture	5
2	Leadership																		Employee training	6
3	Teamwork																		Initiative	4
3	Teamwork																		Culture	5
3	Teamwork																		Employee training	6
4	Initiative																		Culture	5
4	Initiative																		Employee training	6
5	Culture																		Employee training	6

References

1. *Economic Profile*; U.S. Department of State's Bureau of International Information: Washington, DC, USA, 2017.
2. Shiau, Y.-R.; Chang, H.-M. Implementation of lean manufacturing in production processes. *J. Qual.* **2020**, *27*, 5.
3. Anuar, A.; Othman, N.; Sadek, D.M.; Hami, N.; Mansor, N.S. Exploring the Challenges and the Implementation of Lean Practices under Lean Transformation Project in Malaysian Small and Medium Enterprises. *J. Pengur.* **2023**, *67*, 1–3.
4. Tortorella, G.L.; Fettermann, D. Implementation of Industry 4.0 and lean production in Brazilian manufacturing companies. *Int. J. Prod. Res.* **2018**, *56*, 2975–2987. [CrossRef]
5. Wickramasinghe, V.; Wickramasinghe, G.L.D. Effects of HRM practices, lean production practices and lean duration on performance. *Int. J. Hum. Resour. Manag.* **2020**, *31*, 1467–1512. [CrossRef]
6. Knapi, V.; Rusjan, B.; Boži, K. Importance of first-line employees in lean implementation in SMEs: A systematic literature review. *Int. J. Lean Six Sigma* **2023**, *14*, 277–308. [CrossRef]
7. Knol, W.H.; Slomp, J.; Schouteten, R.L.J.; Lauche, K. Lean and action learning: Testing 'critical success factors' using Necessary Condition Analysis. *Int. J. Prod. Res.* **2018**, *56*, 3955–3973. [CrossRef]
8. Vanichchinchai, A. Relationships between leadership and culture, human resources and process improvement in lean healthcare. *Bus. Process Manag. J.* **2023**, *29*, 430–446. [CrossRef]
9. Lizarelli, F.L.; Chakraborty, A.; Antony, J.; Jayaraman, R.; Carneiro, M.B.; Furterer, S. Lean and its impact on sustainability performance in service companies: Results from a pilot study. *TQM J.* **2023**, *35*, 698–718. [CrossRef]
10. Saabye, H.; Powell, D.J.; Coughlan, P. Lean and action learning: Towards an integrated theory? *Int. J. Oper. Prod. Manag.* **2023**, *43*, 128–151. [CrossRef]

11. Gholizadeh, R.H.; Kerman, N.T.; Ahmadi, M.; El-Farr, H.; Lotfi, H.; Akhoondi, M.; Baigi, S.A.S. A Systematic Review and Synthesis of Empirical Research on "Knowledge Leadership". A New Insight in the Field of Knowledge Management. *Int. J. Inf. Sci. Manag.* **2022**, *20*, 169–192.
12. Sawhney, R.; Treviño-Martinez, S.; de Anda, E.M.; Tortorella, G.L.; Pourkhalili, O. A Conceptual People-Centric Framework for Sustainable Operational Excellence. *Open J. Bus. Manag.* **2020**, *8*, 1034–1058. [CrossRef]
13. Bhasin, S. Lean and Performance Measurement. *J. Manuf. Technol. Manag.* **2008**, *19*, 670–684. [CrossRef]
14. Lucey, J.; Bateman, N.; Hines, P. Why Major Lean Transitions Have Not Been Sustained. *Manag. Serv.* **2005**, *49*, 9–13.
15. Sezen, B.; Karakadilar, I.S.; Buyukozkan, G. Proposition of a Model for Measuring Adherence to Lean Practices: Applied to Turkish Automotive Part Suppliers. *Int. J. Prod. Res.* **2012**, *50*, 3878–3894. [CrossRef]
16. Marodin, G.; Saurin, T. Implementing lean production systems: Research areas and opportunities for future studies. *Int. J. Prod. Res.* **2013**, *51*, 6663–6680. [CrossRef]
17. Chen, X.; Kurdve, M.; Johansson, B.; Despeisse, M. Enabling the twin transitions: Digital technologies support environmental sustainability through lean principles. *Sustain. Prod. Consum.* **2023**, *38*, 15. [CrossRef]
18. Jasti, N.V.K.; Kodali, R. Lean Production: Literature Review and Trends. *Int. J. Prod. Res.* **2015**, *53*, 867–885. [CrossRef]
19. Eaton, M. Why change programs fail. *Hum. Resour. Manag. Int. Dig.* **2010**, *18*, 37–42. [CrossRef]
20. Atkinson, P.P. Lean is a cultural issue. *Manag. Serv.* **2010**, *54*, 35–44.
21. Bhasin, S. Prominent obstacles to lean. *Int. J. Product. Perform. Manag.* **2012**, *61*, 403–425. [CrossRef]
22. Loyd, N.; Harris, G.; Gholston, S.; Berkowitz, D. Development of a lean assessment tool and measuring the effect of culture from employee perception. *J. Manuf. Technol. Manag.* **2020**, *31*, 1439–1456. [CrossRef]
23. Bortolotti, T.; Boscari, S.; Danese, P. Successful Lean Implementation: Organizational Culture and Soft Lean Practices. *Int. J. Prod. Econ.* **2015**, *160*, 182–201. [CrossRef]
24. Magnani, F.; Carbone, V.; Moatti, V. The human dimension of lean: A literature review. *Supply Chain. Forum Int. J.* **2019**, *20*, 132–144. [CrossRef]
25. Holmemo, M.D.-Q.; Rolfsen, M.; Ingvaldsen, J.A. Lean thinking: Outside-in, bottom-up? The paradox of contemporary soft lean and consultant-driven lean implementation. *Total Qual. Manag. Bus. Excell.* **2018**, *29*, 148–160. [CrossRef]
26. Prasad, D.S.; Pradhan, R.P.; Gaurav, K.; Chatterjee, P.P.; Kaur, I.; Dash, S.; Nayak, S. Analysing the critical success factors for implementation of sustainable supply chain management: An Indian case study. *Decision* **2018**, *45*, 3–25. [CrossRef]
27. Saaty, T.L. *The Analytic Hierarchy Process*; McGraw-Hill: New York, NY, USA, 1980.
28. Saaty, T.L. *Decision Making with Dependence and Feedback: The Analytic Network Process*; RWS Publications: Pittsburgh, PA, USA, 1996.
29. Shapira, A.; Goldenberg, M. AHP-based equipment selection model for construction projects. *J. Constr. Eng. Manag.* **2005**, *131*, 1263–1273. [CrossRef]
30. Chen, W. Employ Analytic Network Process for Selecting Outsourcing Companies. Master's Thesis, National Chiao Tung University, Hsinchu, Taiwan, 2007.
31. Darko, A.; Chan, A.P.C.; Ameyaw, E.E.; Owusu, E.K.; Pärn, E.; Edwards, D.J. Review of application of analytic hierarchy process (AHP) in construction. *Int. J. Constr. Manag.* **2019**, *19*, 436–452. [CrossRef]
32. Saaty, T.L. *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*; Analytic Hierarchy Process Series; RWS Publications: Pittsburgh, PA, USA, 2000; Volume 6.
33. Chang, L.-L. Construction on Evaluation Indicators for Urban Redevelopment Indicators. Ph.D. Thesis, National Chengchi University, Taipei, Taiwan, 2000.
34. Guerriero, V. Power Law Distribution: Method of Multi-scale Inferential Statistics. *J. Mod. Math. Front.* **2012**, *1*, 21–28.
35. Januszek, S.; Macuvele, J.; Friedli, T.; Netland, T.H. The role of management in lean implementation: Evidence from the pharmaceutical industry. *Int. J. Oper. Prod. Manag.* **2022**, *43*, 418–419. [CrossRef]