A Decision-making Model for Selecting a Process Manager of IPD Manufacturing

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Abstract

Developed after reviewing research papers and conducting questionnaires according to the Delphi Method, this study discusses different types of criteria by choosing 13 suitable sales leaders for the multi-layer ceramic capacitor (MLCC) industry, and comes up with 4 types of evaluation prospects and 22 criteria, in order to establish the weights and priorities of the criteria through the Analytic Hierarchy Process (AHP) method. The goal is to identify which criteria are the critical factors for choosing a production leader. The findings present that expertise capability is the top priority factor when assessing candidates, followed by personality traits and leadership, especially in the area of professional knowledge, moral integrity, and experience, which are the most important factors to consider. Using AHP techniques can thus assist the manufacturing industry in selecting production leaders so as to make better decisions scientifically.

Keywords: technology industry, process supervisor, Delphi Method, Analytic Hierarchy Process.

JEL Classifications: D22, D91, C53, C61.

1. Introduction

1.1. Background

The global multi-layer ceramic capacitor (MLCC) industry underwent a supply shortage in Q4 of 2017. In response to the demand for automobiles, industrial applications, and iPhones, various capacitor manufacturers began strategically reducing the production of medium and high capacitor products for mid- and low-level applications starting in the second half of 2016,

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releasing roughly 20% of manufacturing capacity for standard capacitors. Moreover, the increase in market demand, the Taiwan government's Go South Policy, and continued cross-strait economic and technical exchanges, contributed to supply shortages of MLCC products.

1.2. Motivation

Diverse and complicated MLCC production processes hinder the control of production yield, consequently impacting factory capacity. Control is crucial in the entire production chain, and the ability of process supervisors to lead their engineers and improve product yield is vital in the manufacturing industry. The production process of MLCCs encompasses a number of complex manufacturing procedures involving chemical substances, mechanics, electrical engineering, stress, and thermal dynamics.

This study finds that the selection and promotion of key professionals are extremely meaningful to employees and organizations. However, existing empirical findings on the criteria influencing the promotion of key professionals are scant and lack comprehensiveness. To develop a practical and comprehensive set of selection and promotion regulations that facilitate companies in the selection of mid- or high-level executives to improve company performance, we employ the analytic hierarchy process (AHP) to assess the decision-making models of process supervisors in an anonymous technology company.

1.3. Purpose

The purpose of this study is to identify the foremost abilities that are assessed in the selection of process supervisors.

1. We examine the dimensions and criteria involved in the selection of process supervisors and establish a decision-making model.

2. We employ the Delphi Method (DM) to select the dimensions and criteria and establish a hierarchical framework.

3. We use the analytic hierarchy process to calculate and validate the importance of weights and rankings for the selection of process supervisors.

2. Literature Review

Drucker (1989) notes that the success of a business hinges on the qualities and performance of its managers.

2.1. Leadership

Leadership is the process of influence, and the quality of leadership determines the success or failure of an organization.

2.1.1. Definition of Leadership

Leadership is the process of commanding, guiding, or influencing others in their selection and completion of objectives. People with leadership skills are motivated to improve and evoke others to actively and passionately involve themselves in their work (Gaither, 2004). Okorie (2019) explores the leadership of companies' top management, revealing the principal qualities of a good leader to be: 1) accessibility and dedication, 2) neutrality and modesty, 3) aspiration and attentiveness, 4) believe and aptitude, 5) dignity and amiability, 6) insight and confidence, 7) vitality and concentration, 8) originality and honesty, 9) responsibility and team spirit, 10) decency and self-assurance, 11) charitable, 12) comical and maintenance culture, and 13) reliability (Okorie, 2019).

2.1.2. Criteria for Measuring Leadership

The research indicators for leadership-associated criteria are as follows.

1. Boost morale: On-duty leaders should consistently show concern to the work and personal lives of organizational employees, motivate workplace morale, boost work spirit, and inspire honor and a sense of responsibility (Wang, 2012).

2. Organizational identity: Jucius (1979) defines organizational identity as the sense of pride in being a part of an organization and internalizing organizational objectives as part of the employees' personality, prompting them to center their efforts on the growth and development of the organization.

3. Community spirit: Leaders should lead by example and set a good one. They should apply different techniques to stimulate their subordinates' work commitment and passions, thereby achieving pre-established objectives of the group (Lin, 2009).

4. Organizational innovation: Zaltman (1973) describes organizational innovation as a series of processes to achieve organizational objectives, including conceptualization, evaluation, and deduction. Innovation challenges stagnation in an attempt to meet or transcend corporate objectives.

5. Communication coordination: Communication refers to the conveyance of ideas among

people. Anderson and Narus (1990) state communication coordination as the broad exchange of meaningful and timely information between team members through formal and informal means. Coordination refers to the positive interactions between various departments within an organization.

6. Supervision and guidance: Barry (1996) consolidates seven factors pertaining to management behaviors and defines supervision and guidance as the organizational, leadership, evaluator, and supervisory behaviors imposed by supervisors on their subordinates.

2.2. Personality Traits

Personality traits refer to individuals' permanent psychological features. These features could be distinct extrinsic behaviors or inherent tendencies.

2.2.1. Definition of Personality Traits

Personality refers to a set of characteristics governing the individual's actions, thoughts, habits, speech, and reactions (Magnusson, 1989).

Personality is shaped by numerous characteristics. These characteristics are also known as psychological features or personality traits. At present, researchers widely accept the personality definition proposed by Allprot (1961). Allport believes that people do not passively adapt to the environment, but rather there are active and meaning components. Thus, the researcher revises the meaning of personality as "the dynamic organization within an individual's psychological system that defines his/her behaviors and thoughts" (Allport, 1961).

2.2.2. Five Major Personality Traits

The personality classification method by Costa and McCrae (1986) is one of the most broadly used classification approaches in studies on personality. The researchers classify personality into five major traits: 1) Agreeableness; 2) Conscientiousness; 3) Extraversion; 4) Emotional Stability; and 5) Openness to Experience (Wang, 2019).

2.2.3. Criteria for Measuring Personality Traits

Costa and McCrae (1986) propose eight selection sub-criteria for the measurement of the five major personality traits.

1. Moral integrity: It is the dedication and loyalty of an individual in pursuing his/her objectives, whereby those with fewer objectives focus more on them and demonstrate higher diligence and integrity.

2. Interpersonal field: It is the measure of thought, emotion, and action of the interaction within a continuous dimension spanning from sympathy to opposition, individuals' tolerance and curiosity to unfamiliar object and events, as well as their tendency to actively pursue and gain experiences.

3. Emotional management: Goleman (1995) defines it in Emotional Intelligence as "feelings, specific thoughts, physical state, mental state, and relevant behavioral tendencies"

4. Mental field: It is the objective opinions of intrinsic and extrinsic problems, past and future time orientations, risk tendencies, personal values, routines, and objectives (Ansoff, 1989).

5. Research trial and innovation: It is openness, where individuals with more diverse, superficial interests are more open-minded, imaginative, curious, original, thoughtful, open to new ideas and change, and interested in learning new knowledge and skills.

6. Outgoing and advancing (affinity): It is the measure of thought, emotion, and action of the interaction within a continuous dimension spanning from sympathy to opposition.

7. Positive thinking: It is the tendency to view the positive outcome of problems, tolerance to stress, and healthy mental state (Aspinwall and Taylor, 1997).

8. Self-confidence: It corresponds to self-efficacy by Bandura (1977) in social learning theory, whereby individuals are confident that they can complete a specific task.

2.3. Job Performance

Job performance refers to the quality and quantity of tasks completed by individuals or groups. Campbell (1996) defines job performance as the contribution of employees to their organizations and categorizes performance into efficiency, productivity, and utility.

2.3.1. Definition of Job Performance

Job performance is a vital component for building a robust organization. Job performance is not a short-term objective, but rather should be reflected in the long term and across a magnitude of tasks. Kuo (2019) proposes psychological flexibility at work, or the ability that reinforces employees' intrinsic motivation in pursuing and achieving greater work performance.

2.3.2. Criteria for Measuring Job Performance

Lee (1998) classifies the measurement criteria of job performance into three indices.

1. Efficiency: Completion of tasks within a specific time.

2. Efficacy: Target achievement rate and proposal rate.

3. Quality: Error rate, supervisor satisfaction, customer satisfaction.

Our study develops five selection sub-criteria based on the three indices by Lee (1998).

1. Work efficiency: Robbins (1994) has "efficiency" as whether the time, financial, and human resources required for specific activities are applied economically and whether the outcomes conform to organizational objectives.

2. Work efficacy: Robbins (1994) asserts that "efficacy" emphasizes the pursuit and completion of organizational objectives.

3. Work quality: Garvin (1984) classifies quality into five dimensions.

   (1) Philosophical excellence.

   (2) Products of economics.

   (3) Users of economics, marketing, and operational management.

   (4) Manufacturing and procedures of operational management.

   (5) Value of operational management.

The concept of work quality in this study is similar to that of philosophical excellence, whereby tasks are completed to the highest standard rather than the application of sloppy or incomplete procedures.

4. Work innovation: Drucker (1986) asserts that innovation is a specific tool applied by entrepreneurs. It can be converted into opportunities, developed into different businesses, or applied to provide different services.

5. Work crisis management: Yang (2018) defines crisis management as the prevention or minimization of the effects of crises on the organization, whereby continuous and dynamic monitoring and management processes are maintained.

2.4. Expertise

In a study of the functional approach, Katz (1979) proposes three major skill classifications. Managers' technical skills denote the professional knowledge and skills required to complete specific tasks. The understanding of and specialization in the methods, processes, technical

skills, and knowledge pertaining to specific activities, as well as analytical tool utilization skills in specific domains, are essential for mid-level and base-level managers.

2.4.1. Definition of Expertise

Expertise refers to the skills required in specialized professions. In other words, expertise is the knowledge, skills, attitudes, sentiments, and values required to serve a specific role in a specific profession (Chen, 2000).

2.4.2. Criteria for Measuring Expertise

This study consolidates the definitions of previous studies and develops three criteria to measure expertise: education, experience, and professional knowledge.

1. Education: According to the Chinese Education and Research Network, education is the course of learning scientific and cultural knowledge.

2. Experience: Knowledge acquired through comprehension learning can be widely applied in similar environments. In other words, learners can assimilate similar situations. Ho (2012) proposes that experience entails job experience, professional training, performance, merits, and rewards and penalties.

3. Professional knowledge: Chisholm and Ely (1976) assert that professional competency should entail the following three factors.

(1) Knowledge: It refers to the essential facts and information about the job and the efficient achievement of specific functions through the acquisition of information.

(2) Skill: It refers to the application of knowledge to solve problems, where outcomes can be evaluated by observing actual performance or the performance of specific tasks.

(3) Attitude: It refers to emotional avoidance, which one can evaluate by observing the conversation and behaviors of specific people.

3. Results and Analysis

The Delphi Method (DM) identifies the evaluation criteria for expert consensus. The Analytic Hierarchy Process (AHP) calculates criteria weights. Therefore, this study uses these two methods in order to obtain appropriate results.

3.1. Preliminary Selection of Evaluation Criteria

Figure 1 illustrates the dimensions and criteria used for the preliminary selection of process supervisors in the manufacturing industry.

3.2. Confirming the Evaluation Criteria

We first conduct a literature review to identify the selection criteria. A panel of experts then repeatedly revises the criteria based on their recommendations. The experts' professional knowledge and practice experiences help analyze and consolidate the data, gain consensus, and establish an ideal set of selection criteria.

3.2.1. Expert Scope and Definition

Dalkey (1968) asserts that a panel of at least ten experts should be established to enhance credibility and reduce biases. The 13 experts selected for this study are executive decision-makers who are responsible for selection and promotion.

3.2.2. DM Expert Questionnaire Design

First, we apply DM, in which we invite experts to evaluate the importance of 22 criteria across four dimensions and provide their views and opinions. A high average evaluation indicator score denote high consensus among the experts.

3.2.3. First DM Survey Results and Analysis

In the first survey, the Quartile Deviation (QDs) and Standard Deviation (SDs) of the questionnaires are analyzed to determine whether a consensus is achieved. We then analyze and calculate the interval values provided by the experts for each criterion and omit the dimensions or criteria that failed to achieve a consensus. The results can confirm the criteria for the second DM expert survey. The analysis procedure runs as follows.

1. First survey results: Table 1 tabulates the data dimension results of the first survey, and Table 2 does the same for the data criteria of the first survey.

Table 1: Data Dimensions for the First DM Expert Questionnaire

Facet	SD	Mode	Q.D.	Accept or Reject
Leadership	0.630	4	1	Accept
Personality Traits	0.506	4	1	Accept
Job Performance	1.198	5	2	Reject
Expertise	0.689	4	1	Accept
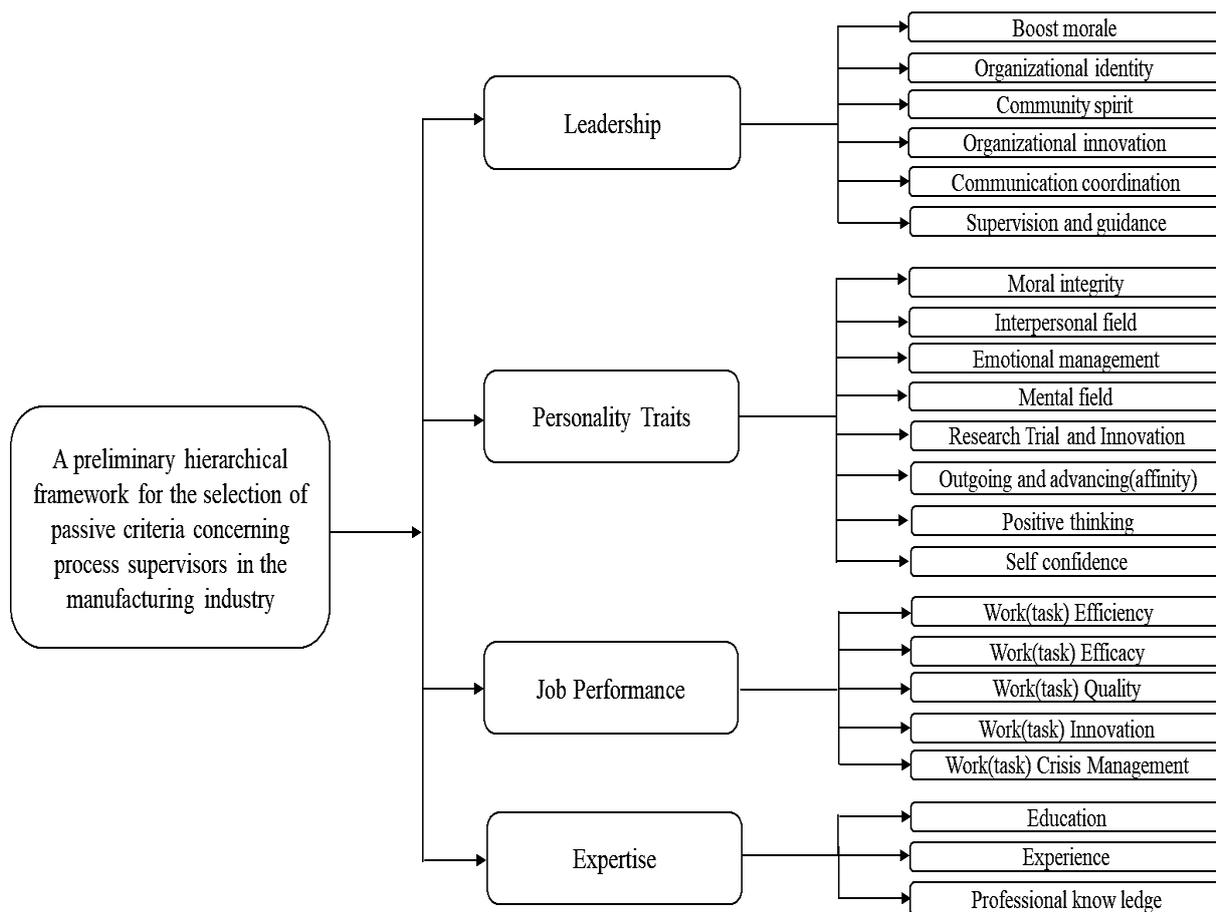
Figure 1: Preliminary Hierarchical Framework for the Selection of Passive Criteria Concerning Process Supervisors in the Manufacturing Industry

2. First survey analysis: We analyze the questionnaire data based on the first expert survey results and adopt QDs as the measure of consistency.

We omit any dimensions and criteria that fail to achieve a moderate-to-high consensus. To achieve moderate-to-high consensus, the original 22 criteria and 4 dimensions drop to 9 criteria and 3 dimensions.

3.2.4. Second DM Survey Results and Analysis

The second survey helps us compare the QDs and SDs to those of the first survey. Convergence is validated when the SDs of the second survey are smaller than or equal to those in the first survey. The results can identify the ideal evaluation criteria for the passive selection of process supervisors in the manufacturing industry. The analysis process runs as follows.

Table 2: Data Criteria for the First DM Expert Questionnaire

Facet	Guidelines	SD	Mode	Q.D.	Accept or Reject
Leadership	Boost morale	0.480	4	1	Accept
	Organizational identity	1.182	2	2	Reject
	Community spirit	0.519	4	1	Accept
	Organizational innovation	1.092	5	2	Reject
Personality Traits	Moral integrity	0.689	4	1	Accept
	Interpersonal field	1.301	3	2	Reject
	Emotional management	0.506	4	1	Accept
	Mental field	1.561	4	2	Reject
	Research trial and innovation	1.000	5	2	Reject
	Outgoing and advancing (affinity)	0.816	4	2	Reject
	Positive thinking	0.630	4	1	Accept
	Self-confident	1.193	2	2	Reject
Job Performance	Work (task) efficiency	1.127	4	2	Reject
	Work (task) efficacy	0.816	3	2	Reject
	Work (task) quality	1.256	2	2	Reject
	Work (task) innovation	1.325	2	3	Reject
	Work (task) crisis management	1.193	5	2	Reject
Expertise	Education	0.689	4	1	Accept
	Experience	0.519	5	1	Accept
	Professional knowledge	0.519	5	1	Accept

1. Second survey results:

Table 3 tabulates the data dimension results of the first survey, and Table 4 does so for the data criteria of the first survey.

Table 3: Data Dimensions for the Second DM Expert Questionnaire

Questionnaire times	First time			Second time			Stability
Facet	SD-S	Mode	Q.D.	SD	Mode	Q.D.	
Leadership	0.630	4	1	0.506	5	1	Stable
Personality Traits	0.506	4	1	0.506	5	1	Stable
Job Performance	1.198	5	2				
Expertise	0.689	4	1	0.519	4	1	Stable

2. Second survey analysis: We analyze the questionnaire data based on the second expert survey results and adopt QDs and SDs as the measures of consistency and stability.

After recovering the second-round DM expert questionnaires, we analyze the QDs to determine whether the subjective opinions of the experts are consistent and examine the differences in the SDs before and after the survey. The results indicate stable convergence. Therefore, two rounds of DM expert questionnaires are administered. We now illustrate the SDs of the dimensions and criteria of the DM expert questionnaire (Figs. 2 and 3).

Table 4: Data Criteria for the Second DM Expert Questionnaire

Questionnaire times		First time			Second time			Stability
Facet	Guidelines	SD-S	Mode	Q.D.	SD	Mode	Q.D.	
Leadership	Boost morale	0.480	4	1	0.480	4	1	Stable
	Organizational identity	1.182	2	2				
	Community spirit	0.519	4	1	0.506	5	1	Stable
	Organizational innovation	1.092	5	2				
	Communication coordination	0.899	3	2				
	Supervision and guidance	0.599	4	1	0.480	4	1	Stable
Personality Traits	Moral integrity	0.689	4	1	0.506	4	1	Stable
	Interpersonal field	1.301	3	2				
	Emotional management	0.506	4	1	0.506	5	1	Stable
	Mental field	1.561	4	2				
	Research trial and innovation	1.000	5	2				
	Outgoing and advancing (affinity)	0.816	4	2				
	Positive thinking	0.630	4	1	0.506	5	1	Stable
	Self-confident	1.193	2	2				
Job Performance	Work (task) efficiency	1.127	4	2				
	Work (task) efficacy	0.816	3	2				
	Work (task) quality	1.256	2	2				
	Work (task) innovation	1.325	2	3				
	Work (task) crisis management	1.193	5	2				
Expertise	Education	0.689	4	1	0.519	5	1	Stable
	Experience	0.519	5	1	0.519	5	1	Stable
	Professional knowledge	0.519	5	1	0.480	5	1	Stable
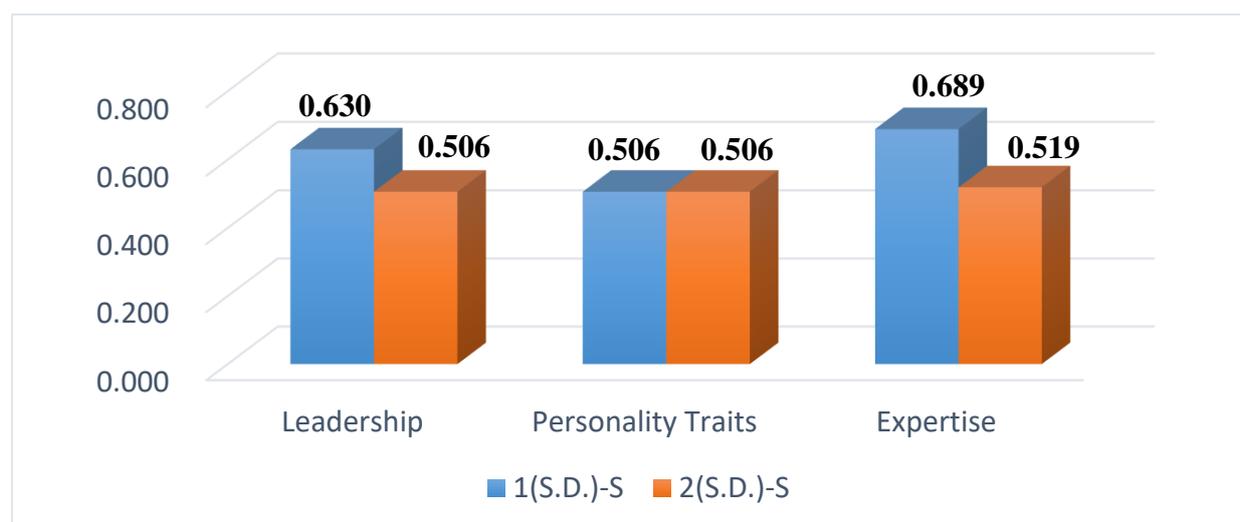
Figure 2: Comparison of the SDs of the Dimensions between the Two Survey Rounds

	Boost morale	Community spirit	Supervision and guidance	Moral integrity	Emotional management	Positive thinking	Education	Experience	Pofessional knowledge
■ 1(S.D.)-S	0.480	0.519	0.599	0.689	0.506	0.630	0.689	0.519	0.519
■ 2(S.D.)-S	0.480	0.506	0.480	0.506	0.506	0.506	0.519	0.519	0.480
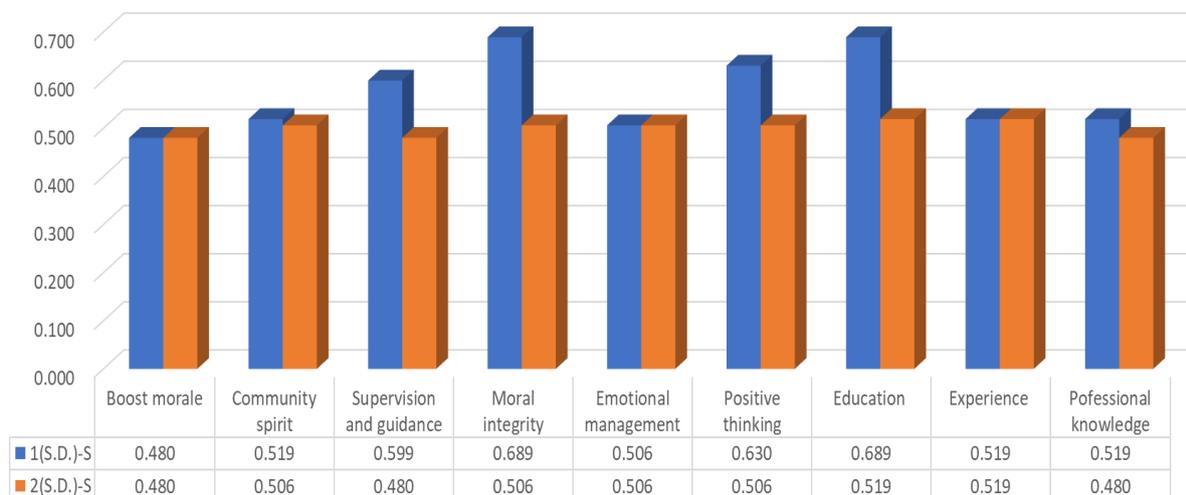
Figure 3: Comparison of the SDs of the Criteria for the Two Survey Rounds

3.2.5. *Validating the Evaluation Dimensions and Criteria*

After the second DM expert survey, we confirm the dimensions and criteria for the AHP questionnaire (Fig. 4).
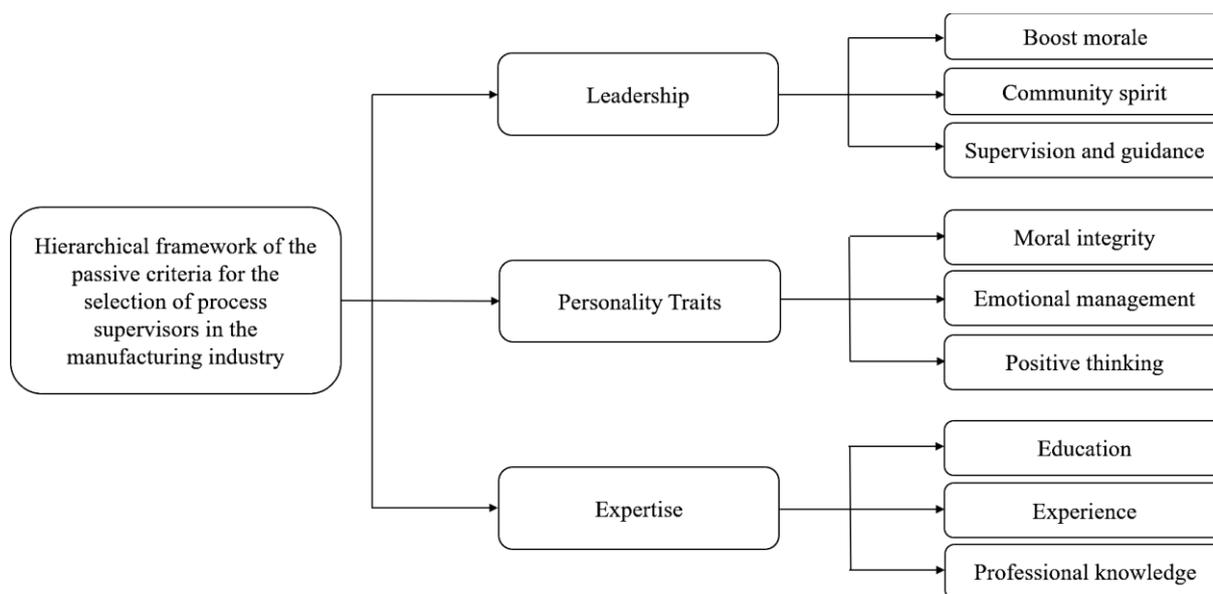
Figure 4: Hierarchical Framework of the Passive Criteria for the Selection of Process Supervisors in the Manufacturing Industry

3.3. *AHP-level Analysis*

AHP decomposes complex problems into a hierarchical system. Different scales can then compare the criteria, and the results are quantified and assessed to resolve specific semi-structured decision-making problems. For decision-makers, hierarchical structures can help them to understand matters and events. These structures also provide sufficient information for

decision-makers to select the ideal solution. Therefore, AHP is a method that enables decision-makers to structurally analyze problems and determine the ideal order for alternative solutions and provides sufficient information concerning the solutions to minimize erroneous decisions.

3.3.1. Administering the AHP Expert Questionnaires

Based on the results of the first DM survey, we select the dimensions and criteria that achieve expert consensus and then administer the AHP questionnaire to the original panel of experts, totaling 13 questionnaires. We recover 12 valid questionnaires for a valid recovery rate of 92.3%.

3.3.2. Calculating the Weights of The Various Dimensions and Criteria and Testing Consistency

The analysis results for the dimensions and criteria are as follows.

1. Analysis of the dimension weights: Among the dimensions, the weight for the "Expertise" dimension is the highest (0.763). The consistency index (CI) and the consistency ratio (CR) are 0.026 and 0.045, respectively, suggesting that the dimensions achieve excellent consistency (Fig. 5).
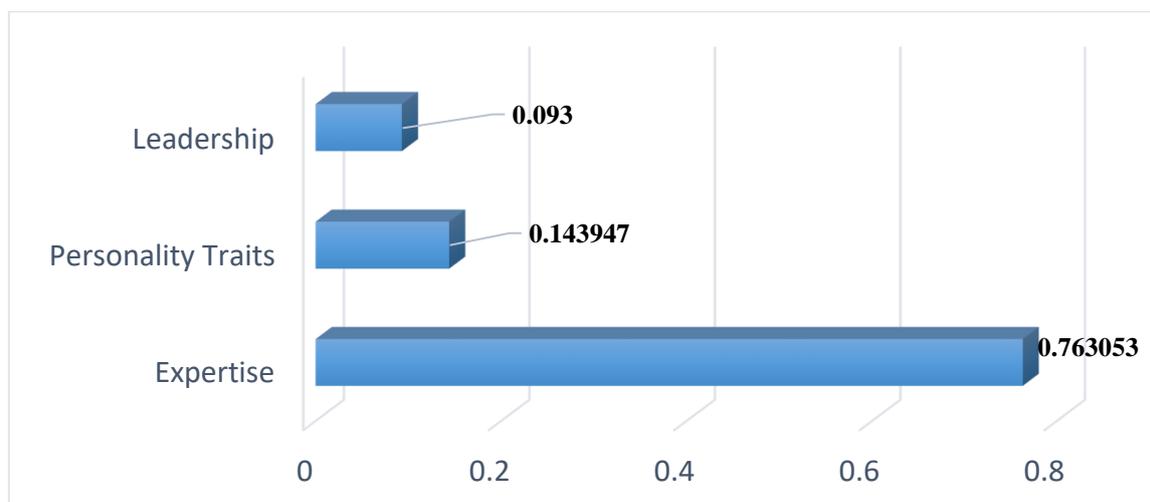
Figure 5: Weight Analysis of the Hierarchical Criteria

2. Analysis of the criterion weights:

(1) In the "Expertise" dimension, the weight for "Professional knowledge" is the highest (0.760). CI and CR are 0.014 and 0.025, respectively, suggesting that the three criteria in the "Expertise" dimension achieve excellent consistency (Fig. 6).
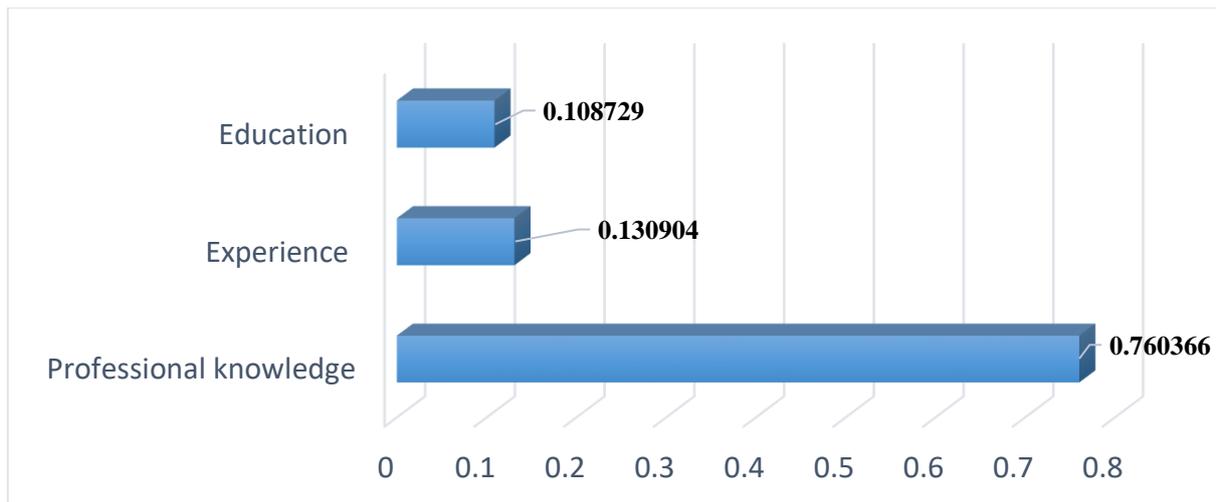
Figure 6: Weight Evaluation of the "Expertise" Criteria

(2) In the "Personality traits" dimension, the weight for "Moral integrity" is the highest (0.760). CI and CR are 0.022 and 0.039, respectively, suggesting that the three criteria in the "Personality traits" dimension achieve excellent consistency (Fig. 7).
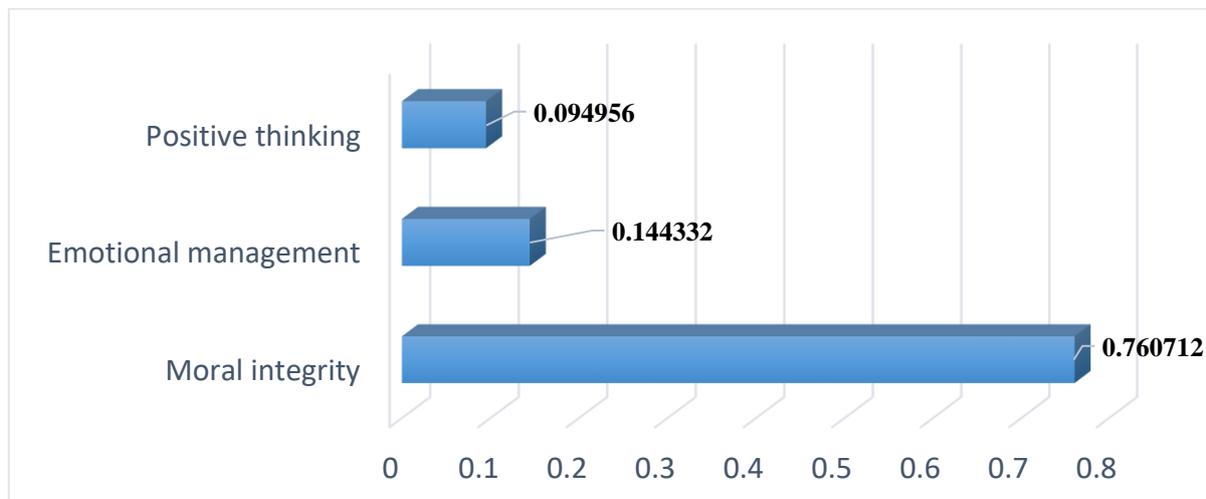
Figure 7: Weight Evaluation of the "Personality Traits" Criteria

(3) In the "Leadership" dimension, the weight for "Supervision and guidance" is the highest (0.766). CI and CR are 0.014 and 0.025, respectively, suggesting that the three criteria in the "Leadership" dimension achieve excellent consistency (Fig. 8).
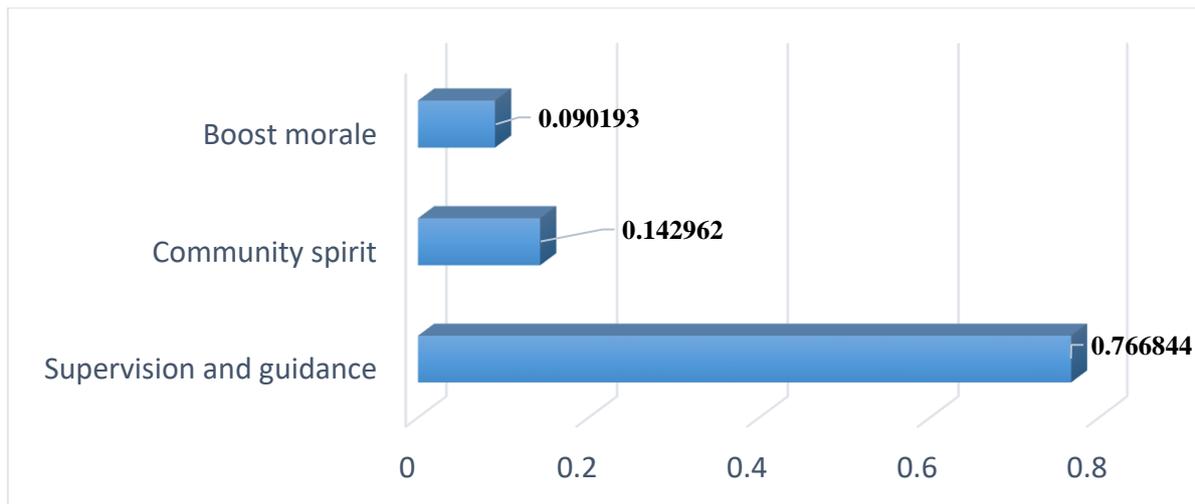
Figure 8: Weight Evaluation of the "Leadership" Criteria

3.3.3. Confirming the Dimension and Criterion Weights of the Passive Criteria for the Selection of Process Supervisors in the Manufacturing Industry

The relative weights of the three dimensions (Expertise, Personality traits, and Leadership) are 76.3%, 14.3%, and 9.3%, respectively. Figure 9 presents the order of the criteria weights.
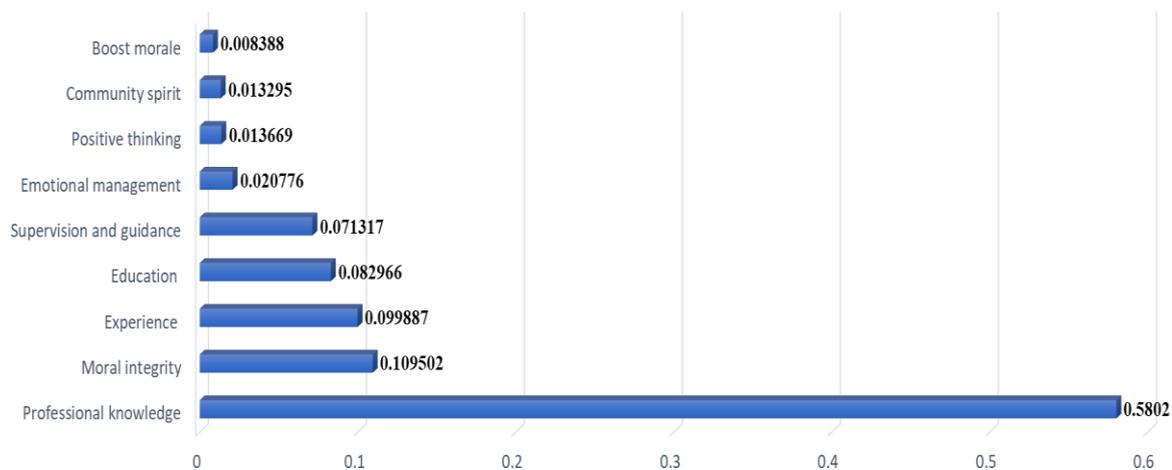
Figure 9: Graph of the Overall Weights

4. Conclusions

1. Professional knowledge (criterion weight 76%; overall weight 58%): The expert panel concede that professional knowledge is a crucial criterion for evaluating the competency of process supervisors in the manufacturing industry. These results appear by examining the selection and promotion of engineers to base-level supervisors and take into account the complexity of MLCC processes and procedures. Therefore, they conform to relevant practices.

2. Moral integrity (criterion weight 76%; overall weight 10.9%): The expert panel concede

that moral integrity, which encompasses discipline, rule abidance, cautiousness, and responsibility, is a crucial criterion.

3. Experience (criterion weight 13%; overall weight 9.9%): The expert panel concede that experience, professional training, performance evaluation, and reward and penalty are fundamental criteria.

4. According to the Delphi Method, job performance is not an important index, because the MLCC manufacturing field has different standards of job performance. Standard job performance is not the same the sales department. Therefore, the job performance of the engineering field has a low priority index.

5. The results of this study are not only applicable to the MLCCs industry, but also provide a selection approach as a reference for process supervisors in other industries.

Acknowledgement

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