

Manufacturing Industry Performance Appraisals: Multi-Criteria Decision-Making Model

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Abstract: Companies with assessment criteria often consider only the leader's subjectivity and ignore other criteria. Limited appraisal criteria result in shortcomings in the decision-making process. This study examines the performance appraisal in a plastic manufacturing company's production floor and develops a multi-criteria decision-making model for performance appraisal by considering company criteria. We propose a qualitative approach using the analytic network process to determine the weighted criteria and sub-criteria to evaluate performance by involving all criteria. The results show that qualitative performance criteria yield higher scores for workers than the quantitative performance criteria, thereby confirming that subjectivity and qualitative criteria influence performance appraisal in the manufacturing industry. A multi-criteria decision-making model is required in performance appraisals to determine the overall measurable criteria. Moreover, this study contributes to an empirical solution for achieving an effective human resource management system.

Keywords: Analytic network process, decision analysis, manufacturing industry, multi-criteria decision making, performance appraisal

1. Introduction

Human resources are necessary to conduct production processing and directly or indirectly affect the company's productivity [1-3]. The quality of human resources performance, particularly workers on the production floor, determines the success of achieving the company's objectives [4-6]. The competent staff is needed because expertise and competence can improve a worker's performance and achievements [7, 8].

This study was conducted on the production floor at a plastic manufacturing company with various jobs and requires the development of performance appraisals with detailed role-related criteria. These performance-appraisal criteria were also used as a basis for determining contract extension. Performance appraisals conducted for production-floor workers were based only on criteria involving the fulfillment of production targets and attendance data and were still subjective based on the leadership's assessment, causing considerable inequity for workers.

Currently, performance appraisal is an efficient approach for employee development and evaluation [9, 10]. Although performance appraisal is an efficient approach, it is also critical for companies and their workers [11]. Several studies propose that managers identify the company's most important criteria because these criteria significantly affect employee performance [12-15]. As it is known that performance appraisal is inseparable from the subjective appraisal, the fairness of performance appraisal will be positively related to motivation to improve employee performance [16-18]. Therefore, decision-makers must use valid methods for decision-making.

Various assessment methods have been applied, such as total quality management, data envelopment analysis, and multi-criteria decision-making (MCDM). Weighting is crucial in decision-making. MCDM has been widely used for weighting criteria [19, 20]. The analytic hierarchy process (AHP) is among the most accepted methods for weighting [21]. However, in the last few studies, AHP could not complete decision-making without a hierarchy [11]. In performance appraisal, many decisions cannot be arranged hierarchically [22]. The analytic network process (ANP) provides a framework as a generalization of AHP. Recently, the use of ANP has increased in most scientific fields compared with AHP [23].

Based on these descriptions, this study aims to develop a performance appraisal model and determine each criterion's weight using MCDM in combination with ANP. The following three questions guided this study:

- RQ1. What criteria and sub-criteria are required in the performance appraisal of workers on the production floor in a manufacturing company?
- RQ2. How to determine the weight for each of the criteria and sub-criteria in the performance appraisal?
- RQ3. How can leaders as decision-makers conduct performance appraisal optimally?

This study contributes empirically to management developments, especially while assessing worker performance. The development of a multi-criteria decision-making model helps company leaders conduct clear and measurable performance assessments. In addition, appropriate performance assessments can be applied as a basis for performance appraisals conducted correctly and equitably to encourage creating an effective human resource management system.

In this paper, we first identify the performance criteria and sub-criteria on a manufacturing company's production floor. Second, we develop and calculate their weightings using the ANP. Third, a rating scale was used to finalize the total performance appraisals. Fourth, we represent evaluation and recommendation for improving decision-making for efficient performance appraisal.

2. Literature Review

Organizational management requires performance management to identify, measure, manage and develop the performance of human resources in an organization. Several references mention terms frequently used in performance management, such as performance assessment, performance appraisal, or employee appraisal. In this study, performance assessment measures how well workers apply their knowledge, skills, and abilities by demonstrating the intended skills [24]. Meanwhile, performance appraisal is part of the overall performance management process, defined as a formal evaluation and appraisal by their managers to achieve objective personnel decisions [25]. However, workers do not always view this as a positive measure, particularly in terms of justice. Improving organizational justice leads to performance efficiency and higher job satisfaction [26]. Although organizational justice is related to fair resource allocation, it still depends on the leadership's ability to impart fair decisions [27]. Therefore, leaders must develop a fair performance appraisal system in their organizations [28, 29]. This appraisal system can be effective if it is fair and reflects the workers' actual performance [30].

Performance appraisal is critical in decision-making, and leaders often use it to assess and develop employee performance in organizations [31]. Decision-making methods on performance appraisal are divided into cognitive or objective and subjective appraisal [32]. Subjectivity cannot be avoided in performance appraisals, and injustice perception will remain [33]. Providing accurate and objective performance appraisals to employees is critical for increasing employee productivity [34]. Successful performance appraisals will increase employee motivation and productivity [35].

Due to the requirement for subjective appraisal of an individual, criteria representing personal competence are required. Personal competence is an important characteristic of an individual that predicts effective performance at work [36]. In this study, we adopted Spencer's criteria, which were also adopted by the company. Spencer's criteria refer to developed personal competence criteria, and McBer and Hay Groups validated it in various countries for 30 years [37, 38]. Overall, there are 20 types of competencies, including achievement orientation, concern for order and initiative.

The number of criteria analyzed and possibly interrelated makes it difficult for these criteria to be arranged hierarchically. Therefore, the development of a multi-criteria decision-making model for performance appraisal in this study was analyzed by ANP, which is a more varied and developed approach and is not limited by AHP [39]. The simplicity of ANP renders this method more general and easier to apply for diverse qualitative studies, such as decision-making and evaluation [40]. After achieving the final weight, the ranked scale integration was used to classify and assess an individual to obtain a clear ranking score performance [41]. Improved employee performance can significantly impact the improvement of the company's performance [42, 43].

3. Research Methods

The qualitative approach was used in this study. Data was collected through observation using questionnaires and interviews in the production floor of a plastic-manufacturing company. This study involved all company leaders on the production floor, namely, one manager and two assistant managers. It also involved all of the contract workers on the production floor, amounting to 68 people as the respondents. Hence, we assume our respondents as the population in this

study. Most of the respondents were males (64%) aged 18–25 years (81%), senior high school holders (78%) and had a work experience of fewer than 5 years (86%).

The initial stage before data processing involved the identification of performance appraisal criteria. It comprised of quantitative and qualitative performance criteria. Quantitative performance criteria were based on the current criteria of the company, i.e. attendance and production targets. Qualitative performance criteria were based on Spencer’s competencies that were modified according to the actual company condition. The stages of determining the needed criteria and sub-criteria were as follows:

- Preparation and dissemination of the first questionnaire, containing 20 competencies (based on Spencer’s performance-management theory) to obtain appropriate criteria.
- Preparation and dissemination of the second questionnaire to obtain appropriate sub-criteria.

During the criteria and sub-criteria selection, statistical methods were also used. These two questionnaires were distributed to all company leaders assessing employees on the production floor. It is intended for the performance assessment criteria following the actual conditions of case studies and ensuring the validity of the questionnaire and content-related validity. The Cronbach’s alpha coefficient yielding $r = 0.841$ was used to check the questionnaire’s reliability. Apart from being most commonly used, we use the Cronbach Alpha coefficient to measure internal consistency reliability because the statements on the distributed questionnaires form a Likert scale [44]. Then, the data was compiled using ANP-derived weightings.

ANP is a mathematical theory that allows a decision-maker to deal with feedback and factors connected to several criteria or multiple-criteria decision-making [45]. The required stages based on ANP are as follows [46]:

- Developing the ANP-based model.
- Using ANP-based pairwise method to apply weightings across the nine scales.
- Using Eigenvector determination for super matrix preparation.
- Determining Consistency Index parameters.
- Making weighted clusters and unweighted super matrix clusters based on the prioritized weighting of interrelated nodes and clusters.
- Making weighted super matrix whose score results from multiplying the scores of cell-cluster matrices with scores of unweight super matrix cells.
- Obtaining the limiting matrix multiplies the weighted super matrix by its own score to obtain global priority weights for each sub-criterion.
- Normalizing the limiting matrix by normalizing groups, thereby deriving a single total priority score for each group.

After deriving the weighted scores, the next step was to evaluate worker performance by applying a rating scale as follows [47]:

- The preparation phase includes setting the topic; determining variables, indicators, predictors and statement items; determining the scale alternatives; determining criteria and preparing observation guidelines.
- The implementation phase includes preparation of observation guidelines, objective observation of behaviour and recording within scale.
- The analysis of the rating scale results is the last step.

We then calculate the total performance appraisal score of workers to obtain the performance of the production workers who are the best and meet the criteria to the ones least meeting the criteria. Based on the employee’s score, company leaders can make decisions regarding individual work contracts’ sustainability. We describe these stages systematically in Figure 1.

4. Results and Discussion

For this study, performance appraisal was conducted using the ANP and the rating scale. Criteria for performance appraisal were made based on criteria currently in use by the company coupled with appraisal criteria based on Spencer competencies [48]. Other criteria were added, so that performance appraisal was based on qualitative and quantitative criteria [49]. Existing criteria based on attendance and production targets are hereafter referred to as quantitative performance criteria (Table 1).

Table 1 - Quantitative performance criteria

Code	Criterion	Information
KK	Work attendance	– At work
		– Permission (not present but with information re absence)
		– Pain (not present but with the doctor’s note)
TP	Production target	– Defaulters (not present, without explanation)
		– Less
		– Average
		– Good

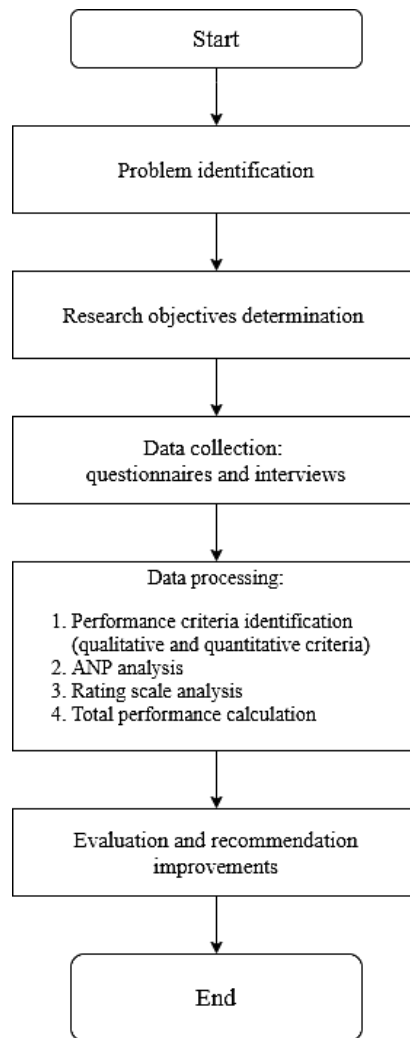


Fig. 1 - Research flowchart

4.1 Qualitative Performance Criteria

Criteria for evaluating workers' performance based on Spencer's performance-management theory are adjusted to the company's needs and circumstances [50, 51]. Of the 20 Spencer competencies, seven criteria were selected according to the results of a distributed questionnaire. These performance-evaluation criteria are then referred to as qualitative. The criteria used in this study were as follows:

- Achievement orientation: The degree of concern for workers to strive to achieve better work.
- Concern for order: Self-encouragement to ensure/reduce uncertainty in the workplace.
- Interpersonal understanding: The ability to understand feelings, desires or thoughts from others.
- Relationship building: The effort to establish and foster warm and close social relations.
- Teamwork: Encouragement or ability to cooperate with others.
- Expertise: Mastery of knowledge related to the job; develop and share knowledge related to the work of others.
- Flexibility: Ability to adapt and work effectively in various situations.

The descriptions of the main criteria were obtained from questionnaires distributed to the leaders [52]. For example, the achievement orientation criteria have sub-criteria focusing on work and enthusiasm for achievement and being proactive (Table 2).

Table 2 - Qualitative performance criteria

Competency criterion	Code	Sub-criteria	Code
Achievement orientation	ACH	Focus on work	ACH1
		Enthusiasm for achievement	ACH2
		Proactive	ACH3
Concern for order	CO	Attention to task clarity	CO1
Interpersonal understanding	IU	Able to understand and help others	IU1
Relationship building	RB	Able to communicate and foster good relations	RB1
		Able to work with others	TW1
Teamwork	TW	Understand and implement supervisors' work instructions	TW2
Expertise	EXP	Able to think analytically and conceptually in their fields	EXP1
Flexibility	FLX	Able to adapt in new place or positions	FLX1

4.2 Quantitative Performance Criteria

Quantitative performance criteria were obtained based on work attendance and production targets. Both these criteria had the same weight determined by the company, 0.5. For comparable (same-scale) scoring between production targets and work attendance, this weight was used to interpolate the rating scales for attendance and production (Table 3).

Table 3 - Quantitative performance criteria scale

Appraisal scale	Production-target score	Work-attendance score
5	≤100	≤100
4	(93.75–99.99)	(87.5–99.99)
3	(87.5–93.74)	(75–87.49)
2	(81.25–87.49)	(62.5–74.99)
1	≤75–81.24	≥50–62.49

4.3 Development of Model Linkage Based on Analytic Network Process

The next step was determining the relation or influence among different criteria or sub-criteria in the same group. Questionnaires were distributed to determine the effects of relations among sub-criteria. We found significant outer dependence (the effects between within-group sub-criteria and different external criteria) as well as inner dependence (influence among sub-criteria within a same-criterion group) [53].

Figure 2 describes criteria as clusters and sub-criteria as nodes in ANP-based linkage models. For example, achievement orientation and focus on the task are clusters and nodes, respectively. The relation of influence among criteria is indicated by arrows [54]. It also shows that each node has a relation between nodes in the same cluster (inner dependence) and nodes (outer dependence).

Four inner dependencies are formed from the achievement orientation cluster/criteria. For example, the sub-criteria focus on the task (ACH1) affects the spirit of achievement (ACH2). These two sub-criteria are sub-criteria in the achievement orientation (ACH) criteria. Therefore, this criterion has inner dependence. Meanwhile, 40 outer dependencies link all sub-criteria. An example is an attention to the clarity of the task (CO1) sub-criteria affecting the proactive sub-criteria (ACH3) on different criteria/clusters.

Pairwise comparisons between cluster nodes are interrelated according to the prior-determined ANP models. If there is inner dependence, it compares nodes in the same cluster or calculates the geometric mean. If there is outer dependence, it compares the same cluster nodes for the external clusters' nodes. Additionally, at this stage, element weights and consistency ratios are calculated through to establishing a super matrix. The result is a super matrix, which comprises three stages—unweighted, weighted and limiting [55].

The weight, normalized by the cluster and obtained via the super matrix limiting stage, shows each sub-criterion's local weight while the limiting score was used to determine each sub-criterion's global weight. Global weight was used as the final weight for each sub-criterion used in assessing worker performance, and then, by summing global weights/sub-criteria, we obtained criteria weights (Table 4). Table 4 shows that the most significant weight for the criteria is ACH, Achievement Orientation, amounting to 0.488. Meanwhile, the FLX criteria, Flexible, has the most negligible weight of 0.012. Therefore, the ACH criteria are a priority in conducting performance appraisals.

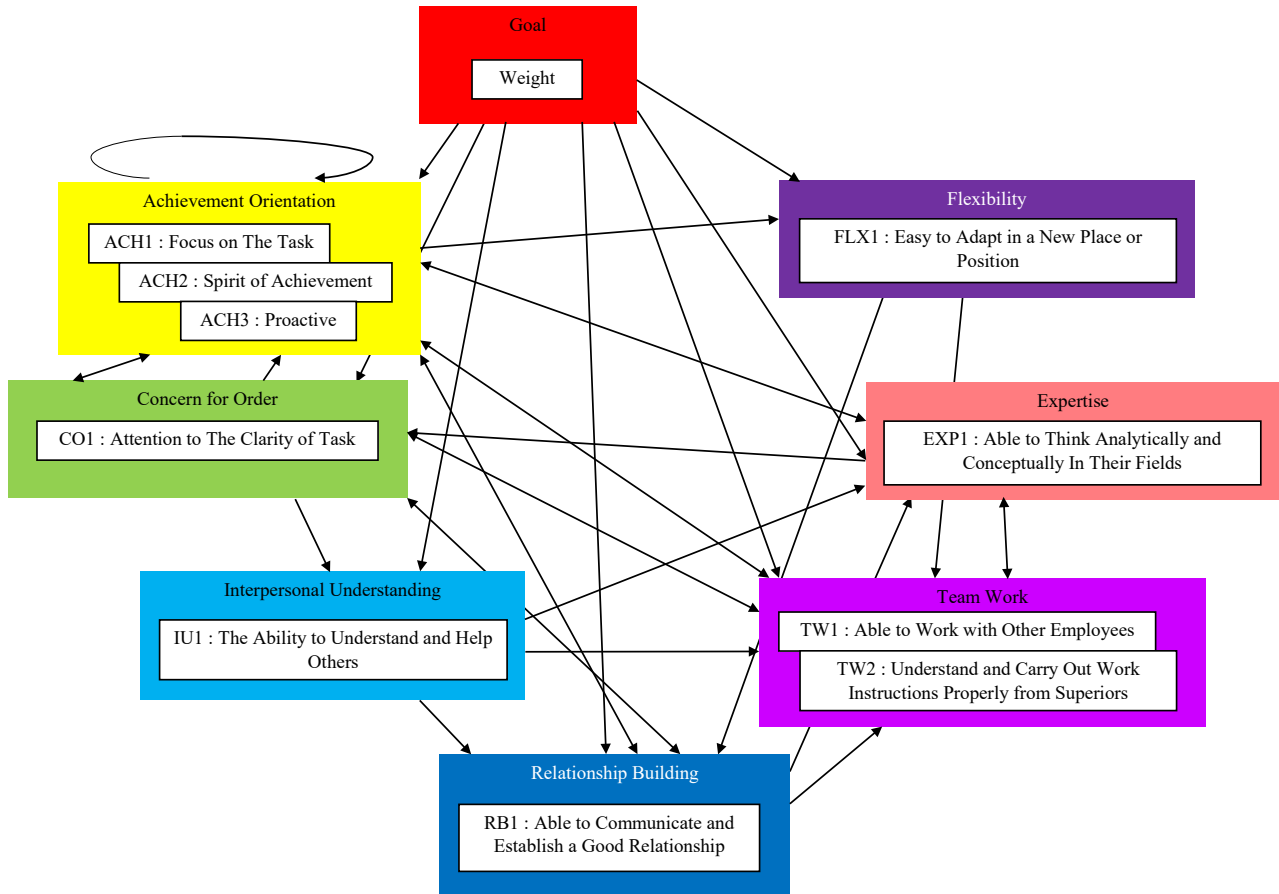


Fig. 2 - Analytic network process linkage model on the production floor at a plastic-manufacturing company

After obtaining the required sub-criteria weights, the rating scale calculation was conducted using a questionnaire to obtain the qualitative scores for each of the performance-evaluation criteria. Each of the questions asked that the expert select a score on a scale of 1–5 (5 representing the highest quality) for a particular worker. Three experts assessed as many as 68 workers to derive qualitative appraisals (Table 5).

Table 4 - Weights of criteria and sub-criteria

Competency criterion	Criterion weight	Sub-criterion	Sub-criterion weight
ACH	0.488	ACH1	0.148
		ACH2	0.042
		ACH3	0.298
CO	0.161	CO1	0.161
IU	0.021	IU1	0.021
RB	0.111	RB1	0.111
		TW1	0.02
TW	0.142	TW2	0.122
		EXP1	0.065
EXP	0.065	EXP1	0.065
FLX	0.012	FLX1	0.012

Table 5 - Example of qualitative appraisals from five workers selected at random

Worker	ACH1	ACH2	ACH3	CO1	IU1	RB1	TW1	TW2	EXP1	FLX1	Total
01	4	3	4	3	4	5	3	3	4	5	3.778
02	2	1	1	1	1	1	1	1	3	1	1.268
04	5	4	3	3	3	5	4	5	4	5	3.913
07	5	4	5	4	3	3	3	4	4	3	4.282
10	5	4	3	5	5	4	5	3	3	3	3.854

4.4 Total Performance Appraisal

Worker performance appraisal conducted in this study used a method based on quantitative and qualitative scores. These scores had different weights: weights for quantitative scores were 75%, and for qualitative weights 25%. For example, if a worker had quantitative and qualitative scores of 3.76 and 3.77, the total performance score was 3.76. Thus, the proposed performance appraisal method in the manufacturing industry, especially for workers on the production floor, uses a multi-criteria decision-making model that considers various criteria before determining the total performance appraisal.

Out of 68 workers assessed, there were 65 workers with high to moderate grades and 3 workers with low scores. The overall performance appraisal results, based on the new criteria and sub-criteria, are represented by the final scores on a scale of 1–5 (Fig. 3). The distribution of scores showed that most workers could continue their employment contracts, while the rest—workers who had low scores—were not allowed to continue their company contracts.

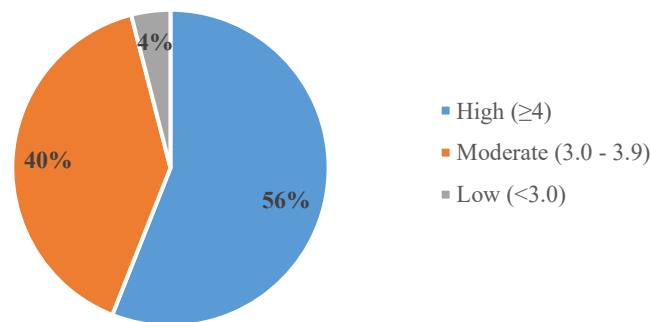


Fig. 3 - Distribution of workers' performance-appraisal scores

4.5 Evaluation and Recommendations for Improvement

Studies of performance appraisal focused on analyzing the performance appraisal analysis for permanent and uncontracted employees [56, 57]. The agreements and workloads between permanent and contract employees significantly differ [58]. In line with Eyoun et al., for contract employees in US hotels, there was a positive correlation between performance appraisal and psychological contract [59]. Therefore, they recommend a performance appraisal to improve contract employees' performance.

This study shows that the optimal appraisal performance is based on quantitative and qualitative scores weighing 0.75 and 0.25, respectively. Quantitative scores consisted of two criteria for appraisal, work attendance and production targets, each having equal weight (0.5). For qualitative scores, we evaluated seven criteria: achievement orientation, concern for order, interpersonal understanding, relationship building, teamwork, expertise and flexibility with weights of 0.49, 0.16, 0.02, 0.11, 0.14, 0.06 and 0.01, respectively.

The analysis showed that dismissed workers had low total scores due to their low qualitative scores. Comparison between the average qualitative and quantitative scores was found to give different mean scores: the average qualitative score was higher, 4.024, while the average quantitative score was 4.020. For instance, among quantitative scores, the production-target criteria had an average score of 3.8, while the work attendance criteria were higher, averaging 4.2. Among the qualitative scores, the lowest average (3.7) was for the sub-criterion of 'able to work with other employees', followed by increasing mean scores for the sub-criteria of 'understand and implement supervisors' work instructions' (3.92), 'able to understand and help others' (3.95), 'able to think analytically and conceptually in their fields' (3.97), 'able to communicate and foster good relations' (3.97), 'proactive' (4.01), 'able to adapt in a new place or positions' (4.04), 'enthusiasm for achievement' (4.17) and 'focus on work' (4.27).

Calculations and ranking scales were used to determine each worker's rank. The highest rating obtained by workers corresponded to a total score of 4.743, while workers with a total score of 2.862 obtained the lowest rank. Based on the lowest calculated scores, three workers were recommended not to continue their employment contracts.

Identifying possible causes of the problem indicates that machine problems and low worker competence lead to low quantitative scores on the production target criteria. The criteria for work attendance were due to the absence of workers. Low qualitative scores were caused by problems with both workers and the work environment. Therefore, recommendations for suggested improvements were determining worker clusters for awarding according to their performance and scheduling training to improve worker competency.

Graded categorization is helpful for a company in determining operators' treatment based on the total score of their performance. For example, categorizing grades are from A to E, where A corresponds to the highest scores. Operator corresponds rewards because the operator has a high total performance score and has shown the best performance.

Training is given to operators in Grades B to D because of the operators' less-than-optimal performance; training in particular competencies would be by the needs or deficiencies of specific operators. As for operators included in Grade E, the company may choose to terminate their employment contracts.

This study indicates that subjective qualitative criteria cannot be separated from performance appraisals. Surprisingly this has a more significant portion than the quantitative criteria that are often measured from company outcomes. Developments and changes may occur in the future because qualitative assessments are based on several criteria and tend to observe processes. This study confirms that the current management development focuses more on a process that is always dynamic [60]. As decision-makers, managers, and perhaps the other company leaders must strive to develop effective performance appraisals for company sustainability. The development of a performance appraisal model with an ANP can be used to compile a clear and good performance appraisal.

5. Conclusions

From the results of this study, we propose using a multi-criteria decision-making model to determine a worker's total performance appraisal in the manufacturing industry, particularly on the production floor. The optimal appraisal performance comprises quantitative and qualitative scores regarding the criteria and sub-criteria of the company. Employees can consider the implications of performance appraisals done well and justice as an investment in their career. It will also increase work motivation, quality and professionalism of the employees themselves and the company performance.

This study contributes to the enrichment of the literature regarding MCDM in performance appraisal but has limitations. They lack budget information related to employees, such as salaries and bonuses, limited exploration on the production floor, and the fact that it focuses only on the related performance criteria. Future studies should investigate this model's effectiveness through a gap study between companies that apply and those who do not apply this performance appraisal model. Furthermore, it can generalize results for other types of employees or organizations and apply other methods to find the most effective for company use and assess the dynamics of human resource practices.

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