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# Enhancing Human Resource Productivity Through a BWM-BSC Framework: A Case Study

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**Abstract** Organizations need to utilize their available resources efficiently and effectively to survive and succeed. Human resources, as one of the most important and valuable organizational assets, play a key role in enhancing productivity. Various factors influence human resource productivity, and the significance of each factor differs across organizations. Therefore, identifying and prioritizing the factors affecting human resource productivity is essential, enabling organizations to plan and set goals to improve the most critical factors. In this study, after reviewing the literature and conducting expert team sessions, 29 factors influencing human resource productivity were identified and finalized in Fars Combined Cycle Power Plant, one of the thermal power plants. These factors were then classified into the four perspectives of the Balanced Scorecard (BSC). Subsequently, the Best-Worst Method (BWM), a trustable method with a high consistency rate for Multi-Criteria Decision-Making (MADM) problems, was used to weight and prioritize the identified factors. The results indicated that the five most important factors affecting human resource productivity are: an adequate salary and compensation system, in-service training, attention to employee needs to enhance motivation, employees' work ethics, commitment and sense of responsibility, and timely payment of salaries and benefits.

**Keyword:** Human Resource Productivity, Balanced Scorecard (BSC), Multi-Attribute Decision Making (MADM), Best-Worst Method (BWM), Consistency Rate, Thermal Power Plant.

## 1 Introduction

Organizations require optimal and effective use of their available resources, including human resources, which are considered the most valuable asset of any organization, to achieve success and sustainability. Various definitions of productivity have been proposed; for instance, productivity is considered the best use of resources to achieve maximum added value or the sum of effectiveness and efficiency [1]. Efforts to enhance human productivity and optimize the use of human resources are considered the vital programs of organizations [2]. Experience shows that one of the most important strategies for organizational development is improving human resource productivity [3]. Previous studies indicate that

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identifying and managing key inefficiencies affecting human resource productivity can significantly improve organizational performance, highlighting the importance of systematic prioritization of these factors [4].

The primary responsibility of managers in any organization is to use resources and capabilities such as labor, capital, materials, energy, and information efficiently. Among these, human resource productivity has particular importance because motivated, capable, and productive individuals can optimally utilize other resources, ultimately leading to an efficient organization [5]. Therefore, identifying the factors affecting human resource productivity in any organization is essential. Organizational capacity-building, including skill development, organizational culture, reward systems, and technology, has been shown to significantly enhance human resource productivity, highlighting the importance of systematically identifying and prioritizing key factors influencing workforce performance [6].

One of the most effective performance evaluation models is the Balanced Scorecard (BSC). This model helps managers create a comprehensive framework to interpret and translate the organization's vision and strategy into a set of performance indicators [7]. The purpose of BSC is to identify key success factors for managers and align organizational performance with overall strategy, thus providing a tool for organizational competitiveness [8,9,10]. Classifying the factors affecting human resource productivity under the BSC perspectives clarifies their role in enhancing productivity and their connection to the organization's vision and strategy. Recent studies have shown that designing conceptual models and systematically evaluating organizational, developmental, maintenance, and welfare factors can help identify key components of human resource productivity and enhance efficiency in industrial and organizational settings [11].

A limitation of the BSC model is that it assigns equal weight to all perspectives and indicators [12], while the importance of different productivity factors varies. Therefore, after identifying and classifying these factors under the BSC perspectives, it is necessary to weight and prioritize them. Multi-Criteria Decision-Making (MADM) methods can be used for this purpose. The BWM, proposed by Rezaei in 2015, requires fewer comparisons than other MADM methods such as the Analytic Hierarchy Process (AHP) and produces more consistent and trustable results [13,14].

Although previous studies have investigated human resource productivity using various decision-making approaches, limited research has simultaneously integrated the BSC framework with a reliable group BWM. In particular, few studies have focused on thermal power plants. Moreover, most existing studies focus either on factor identification or prioritization, without ensuring the consistency and reliability of group decision-making results. Recent studies indicate that designing systematic models for evaluating and enhancing human resource productivity, based on organizational policies and frameworks, can contribute to improving performance and managerial decision-making in industrial and organizational settings [15].

Thermal power plants are a significant subset of the electricity industry and play an important role in national development. The main electricity generation methods in power plants include the use of fossil fuels (thermal: diesel, gas turbine, steam, and combined cycle), nuclear energy, and renewable energy [16]. Given Iran's significant fossil fuel reserves, the majority of the country's electricity generation is based on thermal power plants [17].

To address the identified research gap, this study proposes an integrated BWM–BSC approach to evaluate human resource productivity in a real-world industrial setting. Specifically, this study contributes to the literature by: (1) systematically identifying human resource productivity factors related to sustainable performance in a thermal power plant, (2)



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classifying these factors within the four BSC perspectives, and (3) applying a trustable group BWM with consistency thresholds to weight and prioritize the factors with higher reliability.

In this study, the factors affecting human resource productivity in the Fars Combined Cycle Power Plant, as one of the country's thermal power plants, were first identified. Then, these factors were classified under the BSC perspectives. Subsequently, the trustable BWM technique was applied to weight and prioritize the final factors affecting human resource productivity. Ultimately, the studied organization can plan and set goals to improve the most critical factors identified to enhance human resource productivity.

The structure of this research is as follows: first, the theoretical background and literature review are presented; then, the research methodology is explained; next, the findings are presented and compared with similar studies in the discussion section; finally, the conclusion of the study is provided.

## 2 Theoretical background and literature review

In this section, the theoretical foundations of human resource productivity, the BWM and its consistency, and the BSC are first presented. Then, previous studies on identifying and evaluating factors affecting the improvement of human resource productivity are reviewed.

### 2.1 Human resource productivity

Various definitions of productivity have been proposed in the literature. Productivity represents the combination of effectiveness (the degree of achieving predetermined goals) and efficiency (performing tasks correctly) within an organization [1]. The European Productivity Agency defines productivity in two ways:

productivity as the maximum utilization of resources required in the production process;

productivity as a mindset and way of thinking based on the belief that any task that can be performed tomorrow can be done better today [18].

Productivity has also been defined as maximizing the use of resources—particularly human resources—reducing costs, and increasing the satisfaction of employees, managers, and consumers through scientific methods. In other words, productivity refers to the optimal utilization of labor force capabilities, talents, skills, available resources, time, and space in order to enhance social welfare. Given the direct role of human resources in the production of goods and the delivery of services, human resources are recognized as one of the most valuable assets of any organization and occupy a special position among other production factors. Employees are considered valuable organizational assets, and achieving organizational goals largely depends on the effective management of human resources, as labor force is a key determinant of productivity [19].

Human resource productivity is defined as the optimal utilization of human resources to direct them toward organizational objectives while minimizing cost and time [3]. Efforts to enhance human resource productivity and optimize the use of human resources are considered vital organizational programs. Undoubtedly, human resource productivity is not influenced by a single factor; rather, it is the result of the interaction and integration of multiple factors. Since productivity is not an abstract concept, it must have practical implications. Therefore, organizational management plays a crucial role in providing an appropriate context for institutionalizing and enhancing productivity [2].



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## 2.2 BWM and its consistency

BWM was introduced by Rezaei as a nonlinear model (Model 1) for solving MADM problems, and it is considered the original BWM model. The steps for constructing and solving the original BWM model are as follows:

Step 1: The set of decision criteria is defined as $\{C_1, C_2, \ldots, C_n\}$.

Step 2: The Best (B) and the Worst (W) criteria are identified.

Step 3: The preference of the best criterion over all other criteria ($a_{Bj}$) is determined using a scale from 1 to 9.

Step 4: The preference of all criteria over the worst criterion ($a_{jW}$) is determined using a scale from 1 to 9.

Step 5: By formulating and solving Model (1), the optimal weights of the criteria $(w_1^* . w_2^* . \ldots . w_n^*)$ are calculated.

$$\begin{aligned}
&\min \xi \\
&\text{s.t:} \\
&\left|\frac{w_B}{w_j} - a_{Bj}\right| \le \xi, \forall j \\
&\left|\frac{w_j}{w_w} - a_{jW}\right| \le \xi, \forall j \\
&\sum_j w_j = 1 \\
&w_j \ge 0, \forall j
\end{aligned} \tag{1}$$

To ensure the reliability of BWM results, the CR is calculated based on Equation (2); where $\xi^*$ is the optimal value of the objective function in Model (1), and the Consistency Index (CI), or $\xi_{max}$, is obtained from Table 1. The CR is a numerical value between zero and one. The closer the CR is to zero, the higher the consistency; and the closer it is to one, the lower the consistency [13].

$$CR = \frac{\xi^*}{CI} \tag{2}$$

**Table 1** Consistency indices (CI) [10]

| $a_{BW}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| CI ($\xi_{max}$) | 0.00 | 0.44 | 1.00 | 1.63 | 2.30 | 3.00 | 3.73 | 4.47 | 5.23 |

Subsequently, Liang et al. [20] proposed new approaches for calculating the Input-based Consistency Ratio ($CR^I$) and the Output-based Consistency Ratio ($CR^O$), along with acceptable Consistency Ratio Thresholds (CRT). The $CR^I$ is computed based on pairwise comparison preferences; therefore, after collecting the pairwise comparison data, the $CR^I$ for each criterion is calculated using Equation (3), as proposed by Liang et al. [20], and the maximum $CR^I$ value is considered as the overall $CR^I$ of the decision problem.



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$$CR^{I} = \max_{j} CR_j^{I}$$
$$CR_j^{I} = \begin{cases} \dfrac{|a_{Bj} \times a_{jw} - a_{Bw}|}{a_{Bw} \times a_{Bw} - a_{Bw}} & a_{Bw} > 1 \\ 0 & a_{Bw} = 1 \end{cases} \tag{3}$$

The use of $CR^I$ offers several advantages. One major benefit is immediate feedback, as calculating $CR^I$ does not require solving Model (1). Another advantage is its model independence, meaning that $CR^I$ can be applied to various BWM formulations beyond the original model. In the acceptable threshold tables for $CR^I$ and $CR^O$ (Tables 2 and 3), CRT values are determined based on the number of criteria (from 3 to 9) and the comparison scale ($a_{BW}$) ranging from 3 to 9. Accordingly, if the calculated consistency ratio is smaller than the corresponding acceptable threshold, the results are considered trustable; otherwise, the pairwise comparisons must be re-evaluated [20].

**Table 2** CRT for $CR^I$ [20]

| | | Criteria | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Scales** | **3** | 0.1667 | 0.1667 | 0.1667 | 0.1667 | 0.1667 | 0.1667 | 0.1667 |
| | **4** | 0.1121 | 0.1529 | 0.1898 | 0.2206 | 0.2527 | 0.2577 | 0.2683 |
| | **5** | 0.1354 | 0.1994 | 0.2306 | 0.2546 | 0.2716 | 0.2844 | 0.2960 |
| | **6** | 0.1330 | 0.1990 | 0.2643 | 0.3044 | 0.3144 | 0.3221 | 0.3262 |
| | **7** | 0.1294 | 0.2457 | 0.2819 | 0.3029 | 0.3144 | 0.3251 | 0.3403 |
| | **8** | 0.1309 | 0.2521 | 0.2958 | 0.3154 | 0.3408 | 0.3620 | 0.3657 |
| | **9** | 0.1359 | 0.2681 | 0.3062 | 0.3337 | 0.3517 | 0.3620 | 0.3662 |

**Table 3** CRT for $CR^O$ [20]

| | | Criteria | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
| **Scales** | **3** | 0.2087 | 0.2087 | 0.2087 | 0.2087 | 0.2087 | 0.2087 | 0.2087 |
| | **4** | 0.1581 | 0.2352 | 0.2738 | 0.2928 | 0.3102 | 0.3154 | 0.3273 |
| | **5** | 0.2111 | 0.2848 | 0.3019 | 0.3309 | 0.3479 | 0.3611 | 0.3741 |
| | **6** | 0.2164 | 0.2922 | 0.3565 | 0.3924 | 0.4061 | 0.4168 | 0.4225 |
| | **7** | 0.2090 | 0.3313 | 0.3734 | 0.3931 | 0.4035 | 0.4108 | 0.4298 |
| | **8** | 0.2267 | 0.3409 | 0.4029 | 0.4230 | 0.4379 | 0.4543 | 0.4599 |
| | **9** | 0.2122 | 0.3653 | 0.4055 | 0.4225 | 0.4445 | 0.4587 | 0.4747 |


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Subsequently, several efforts have been made to develop alternative models for solving the BWM in order to obtain more trustable results. Among these, Dehghani and Abbasi proposed a trustable BWM algorithm based on the use of $CR^I$, $CR^O$, and CRT. In this algorithm, after collecting pairwise comparison data, the $CR^I$ of the problem is calculated. Given the high correlation between $CR^I$ and $CR^O$, if the calculated $CR^I$ falls within the acceptable $CR^I$ threshold, the data are considered consistent, and with a high probability, the results of the model will also be consistent. Then, according to the steps of the original BWM, the problem is solved, and finally, if the calculated $CR^O$ also lies within the acceptable $CR^O$ threshold, the results are regarded as trustable [21].

Subsequently, Dehghani and Abbasi developed an algorithm that is capable of solving the nonlinear BWM model by employing multiple linear programming models [22]. Furthermore, Abbasi and Dehghani improved the previous algorithm and proposed a model that achieves results close to those of the nonlinear formulation while solving fewer linear programming models [23]. More recently, Dehghani et al. introduced a robust BWM model designed to address uncertainty conditions [24].

## 2.3 BSC

The objective of the BSC is to identify key success factors for managers and to create alignment between organizational performance and overall strategy. Accordingly, BSC serves as a managerial tool that guides organizations toward competitiveness. Organizations adopting the BSC framework should tailor it to their specific environment as well as their internal processes [8,9].

The BSC translates an organization's strategy and vision into four perspectives: learning and growth, internal business processes, customer, and financial [25]. The financial perspective reflects organizational performance in terms of economic and financial aspects, including cost control, budgeting, and financial management over time. The customer perspective focuses on market share and customer-related outcomes, evaluating organizational performance in achieving customer satisfaction and increasing market share. From the internal process perspective, the organization aims to meet customer and shareholder expectations regarding financial outcomes; collectively, performance across these perspectives determines the organization's competitive position in the market. The learning and growth perspective seeks to provide the necessary conditions for long-term organizational development and improvement [26]. Moreover, the BSC is a managerial technique that enables managers to assess organizational activities and trends—whether growing or declining—from multiple perspectives [27].

## 2.4 Literature review

Amirzadeh Moradabadi et al. investigated the identification of factors affecting human resource productivity and related managerial strategies in the Educational Affairs Department of Bam University of Medical Sciences. The results indicated that among the five key components influencing human resource productivity, leadership style and approach had the greatest impact, while physical environment and workplace conditions had the least effect on improving managers' and employees' productivity. In addition, employee empowerment, individual factors, reward systems, and organizational culture ranked second to fourth in terms of importance [28]. Shojaei et al. classified the factors influencing human resource


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productivity into four main categories: enabling factors, managerial factors, organizational motivational factors, and facilities [29].

Joudaki and Hasanpour identified the factors affecting employee productivity improvement in the National Standards Organization of Iran and prioritized them using the Analytic Network Process (ANP). In this study, five main factors—including management style, individual characteristics, job-related factors, organizational characteristics, and welfare factors—and 36 sub-factors were identified. The results showed that welfare factors were the most important main factor in enhancing employee productivity, followed by management style, job-related factors, individual characteristics, and organizational characteristics. Moreover, the adequacy of salary and compensation levels was identified as the most significant sub-criterion affecting employee productivity in the organization under study [30].

Sadeghi et al. identified and ranked employee productivity functions using an integrated approach based on the BSC and value engineering methodology. The identified productivity functions were classified into the four BSC perspectives, and based on this classification, a function analysis system diagram was developed. The findings revealed that achieving relative welfare in the financial perspective, employee job satisfaction in the customer perspective, motivation creation in the internal process perspective, and the availability of appropriate training in the learning and growth perspective received the highest scores [10].

Azimi examined the factors influencing human resource productivity in construction projects. The results indicated that economic–human factors, managerial factors, social factors, and job characteristics, respectively, had the greatest impact on human resource productivity [31]. Mirsaeidi et al. designed a model for enhancing the human resource productivity system in the National Iranian Oil Company, identifying 36 sub-categories and 13 main categories within a paradigmatic framework aimed at improving human resource productivity [32]. Harati Mokhtari and Younespoor identified and prioritized factors affecting human resource productivity in Chabahar Port using the AHP method. Their findings showed that leadership and management style, alignment between individual interests and job roles, competency-based promotion systems, alignment between individual skills and job requirements, and work conscience were the most influential factors affecting human resource performance [19]. Dehghani and Fekri identified and evaluated factors affecting human resource productivity in line with sustainable production in thermal power plants and emphasized the role of managerial, individual, and organizational factors in enhancing human resource productivity in this industry [33].

In international studies, Sadeghi Fard et al. proposed a model for identifying factors influencing human resource productivity in the affiliated offices of a governmental organization. Their results indicated that various factors, including organizational culture, motivational factors, leadership style, training and empowerment, employee compensation, human resource quality, information technology, organizational structure, and work environment, play significant roles in human resource productivity [34]. Gunduz and Abu-Hijleh evaluated and ranked human resource productivity drivers in the construction industry using risk mapping. They identified poor supervision, delayed payments, unfavorable working environments, shortage of skilled labor, and adverse weather conditions as the most critical factors reducing labor productivity [35]. Sarwar and Sheikh, based on empirical evidence from Pakistan, showed that wages, human capital investment, labor force participation, and inflation have significant effects on labor productivity [36]. Tekin et al. examined the relationships among job satisfaction, quality of work life, life satisfaction, organizational commitment, and labor productivity in the manufacturing industry using structural equation modeling [37].



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Overall, based on previous studies, it can be concluded that in order to enhance human resource productivity in thermal power plants in Iran, it is first necessary to identify, evaluate, and prioritize the factors influencing human resource productivity. Accordingly, the main contributions of this study are as follows**:**

1. Systematic identification, classification, and prioritization of human resource productivity factors in a thermal power plant using an integrated BWM–BSC approach, providing both theoretical insights and practical guidance for managers**.**
2. Application of a trustable group BWM with both $CR^I$ and $CR^O$ calculations, along with CRT, to improve the reliability and consistency of MADM results**.**
3. Demonstrating the practical applicability of the proposed approach in a real industrial setting, specifically a thermal power plant, which has been less studied in prior research.

## 3 Research methodology

The present study is applied in nature based on its objective. Moreover, since both quantitative and qualitative data, along with their corresponding tools, are used simultaneously, the research adopts a mixed-methods approach combining quantitative and qualitative methods.

The theoretical information and preliminary factors affecting human resource productivity were collected using a library-based method and an extensive literature review. After that, field data were gathered using standard BWM questionnaires and structured expert panel sessions. The expert panel consisted of 8 specialists from the Fars Combined Cycle Power Plant, with extensive experience in human resource management and organizational productivity. The panel members were asked to perform pairwise comparisons of the identified factors according to the BWM procedure [13,21].

The study followed these steps: First, human resource productivity factors were identified from literature and expert input. Next, the factors were classified under the four BSC perspectives. Then, pairwise comparison matrices were constructed for BWM analysis. After that, weights and consistency ratios for each criterion were calculated using BWM to ensure reliable and consistent decision-making. Finally, factors were prioritized based on the computed weights to identify the most critical determinants of human resource productivity.

Data analysis was performed using LINGO for BWM calculations and Excel for organizing and summarizing the data. The Proposed Algorithm is described in detail in Section 4, where the step-by-step procedure for weighting and prioritizing human resource productivity factors is fully elaborated.

## 4 Proposed algorithm

In this section, the algorithm employed for identifying and prioritizing the factors affecting the improvement of human resource productivity is presented through the following steps:

Step 0: Problem Preparation and Expert Panel Formation

At this step, the research problem is defined, and an expert panel is formed to support the identification, classification, and evaluation processes.

Step 1: Identification of Problem Criteria (Factors Affecting Human Resource Productivity Improvement).



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In this step, the criteria/factors influencing the improvement of human resource productivity are identified through a comprehensive literature review and expert opinions.

Step 2: Classification of Problem Criteria into the Four BSC Perspectives.

In this step, expert panel sessions are conducted to classify the identified factors affecting human resource productivity improvement into the four perspectives of the BSC.

Step 3: Evaluation and Weighting of the Final Criteria.

In this step, the trustable BWM algorithm proposed by Dehghani and Abbasi [21] is employed to evaluate and weight the final criteria. The four BSC perspectives are considered the main criteria of the problem, collectively forming the highest-level sub-problem (SP1). The sub-criteria related to each BSC perspective constitute four additional sub-problems (SP2 to SP5). Consequently, a total of five sub-problems are defined.

Given that acceptable threshold values for $CR^I$ and $CR^O$ have been provided by Liang et al. (2020) for a maximum of nine criteria, the number of criteria in each sub-problem is limited to nine. If the number of criteria exceeds nine, a hierarchical structure must be developed such that each sub-problem contains no more than nine criteria. Subsequently, the trustable BWM module is applied to calculate the weights of the five sub-problems.

After computing the initial weights of the criteria (factors affecting human resource productivity improvement), the final weights are calculated. In this regard, the initial weights of the level-one main criteria are considered as their final weights. The final weights of lower-level criteria are obtained by multiplying the initial weight of each criterion by the initial weight of its corresponding higher-level criterion(s), as suggested by Dehghani and Abbasi [21].

## 5 Research findings

This section presents and explains the results obtained from implementing the proposed algorithm to evaluate the factors affecting human resource productivity at the Fars Combined Cycle Power Plant. The Fars Combined Cycle Power Plant is one of the thermal power plants in Iran and is located approximately 26 kilometers southeast of Shiraz. The nominal capacity of the power plant is 1035 MW, consisting of six gas units and three steam units.

In Step 0, problem preparation and the formation of the expert panel were conducted. To determine the expert panel members, the snowball sampling method was employed [38]. In this process, the initial members of the expert panel were selected based on the recommendation of the Chief Executive Officer (the highest organizational authority). Since no new experts were introduced by the panel members, the expert panel was considered complete. It should be noted that in the snowball sampling method, when no additional participants are suggested, the sample is regarded as finalized. Furthermore, during the expert panel sessions, in cases where consensus could not be reached on a particular question, the majority vote was adopted as the decision criterion.

Subsequently, according to Step 1 of the proposed algorithm, a total of 29 factors affecting human resource productivity in the studied thermal power plant were identified and finalized through a comprehensive literature review and expert panel opinions, as presented in Table 4.



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**Table 4** Final determinants of human resource productivity

| Row | Factors Affecting Human Resource Productivity | References |
|---|---|---|
| 1 | Management and Leadership Style | [10], [19], [29], [30] |
| 2 | In-service Training | [19], [29], [30], [35] |
| 3 | Competency-based Promotion System | [19], [29], [30] |
| 4 | Succession Planning System | [30] |
| 5 | Non-discrimination and Fairness Among Employees | [10], [29], [30] |
| 6 | Adequate Salary and Compensation System | [19], [29], [36] |
| 7 | Performance-based Payment System | [30], [31] |
| 8 | Transparent Communication Between Managers and Employees | [28], [29] |
| 9 | Relevant Education | [19], [28] |
| 10 | Work Conscience, Commitment, and Responsibility | [19], [30], [31] |
| 11 | Job Security | [10], [19], [30], [31], [35] |
| 12 | Perception of Fair Working Conditions | [19] |
| 13 | Job Satisfaction | [10], [19], [30], [35] |
| 14 | Timely Payments | [31], [35] |
| 15 | Prevention of Resource Wastage | [1] |
| 16 | Work Experience | [28], [29], [30], [31] |
| 17 | Alignment Between Personal Interests and Job Skills | [19], [30] |
| 18 | Creativity and Innovation | [10], [30] |
| 19 | Sufficient Employee Skills and Expertise | [28], [30], [35] |
| 20 | Proper and Logical Distribution of Human Resources | [28] |
| 21 | Proper Reward and Punishment Mechanisms | [28], [31] |
| 22 | Cooperation and Teamwork Spirit | [10], [28], [30] |
| 23 | Physical Work Environment | [19], [30] |
| 24 | Friendly Atmosphere Among Employees | [19] |
| 25 | Job Rotation | [10], [29] |
| 26 | Safety and Comfort at Work | [30] |
| 27 | Attention to Employee Needs to Increase Motivation | [10], [30] |
| 28 | Adequate Tools and Equipment | [19], [28], [30] |
| 29 | Provision of Welfare Facilities and Services | [10] |

Subsequently, according to Step 2 of the proposed algorithm, and through holding sessions with the expert team, the factors influencing human resource productivity were classified into the four BSC perspectives. Therefore, based on the nature of the factors and the experts' opinions, the final factors affecting the enhancement of human resource productivity at Fars combined cycle power plant were categorized into the four BSC perspectives, as presented in Table 5.

Then, according to Step 3 of the algorithm, the final factors affecting human resource productivity were evaluated and prioritized using the trustable BWM. Accordingly, five sub-problems (SP1 to SP5) were formed, which were weighted following the steps of the trustable BWM module. First, the best and worst factors of each sub-problem were determined through sessions with the expert team. Then, the pairwise comparison preference data for each sub-problem (SP1 to SP5) were collected from the experts. Next, the $CR^I$ for each sub-problem was calculated using Equation (3) and compared with the corresponding acceptable threshold extracted from Table 2 (based on the number of indicators and $a_{BW}$ values). Since the $CR^I$ values were smaller than the respective acceptable thresholds, the data were consistent and deemed acceptable. The results of the input-based consistency for the five sub-problems are presented in Table 6.



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**Table 5** Classification of factors affecting human resource productivity across BSC perspectives

| Factors Affecting Human Resource Productivity | BSC Perspectives |
|---|---|
| Appropriate salary and wage system<br>Timely payments<br>Performance-based payment system<br>Prevention of resource wastage<br>Provision of welfare and service facilities | Financial Perspective |
| Appropriate tools and equipment<br>Transparent communication between managers and employees<br>Work ethics, commitment, and responsibility of employees<br>Job satisfaction<br>Perception of fairness in work conditions<br>Alignment between individual interests and job skills<br>Friendly work atmosphere among employees<br>Feeling of safety and comfort in the workplace<br>Physical working conditions | Customer Perspective |
| Job rotation<br>Employee promotion system based on competence<br>Non-discrimination and fairness among employees<br>Establishment of succession planning system<br>Job security<br>Design and implementation of appropriate reward and punishment mechanisms<br>Proper and logical allocation of human resources across departments<br>Attention to employees' needs to increase motivation | Internal Processes Perspective |
| Management and leadership style<br>In-service training<br>Relevant education<br>Work experience<br>Creativity and innovation<br>Employees' sufficient skills and expertise<br>Teamwork spirit and cooperation | Learning and Growth Perspective |

**Table 6** $CR^I$ consistency analysis of the case study subproblems

| Sub-problems | | Values | $C_{X.1}$ | $C_{X.2}$ | $C_{X.3}$ | $C_{X.4}$ | $C_{X.5}$ | $C_{X.6}$ | $C_{X.7}$ | $C_{X.8}$ | $C_{X.9}$ | $CR^I$ | CRT | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP1 | X=1 | $a_{Bj}$ | 1 | 4 | 3 | 2 | - | - | - | - | - | 0.0833 | 0.1529 | Acceptable |
| | | $a_{jW}$ | 4 | 1 | 1 | 2 | - | - | - | - | - | | | |
| SP2 | X=2 | $a_{Bj}$ | 1 | 3 | 3 | 7 | 5 | - | - | - | - | 0.2619 | 0.2819 | Acceptable |
| | | $a_{jW}$ | 7 | 6 | 5 | 1 | 3 | - | - | - | - | | | |
| SP3 | X=3 | $a_{Bj}$ | 5 | 4 | 1 | 3 | 3 | 4 | 7 | 3 | 4 | 0.1905 | 0.3403 | Acceptable |
| | | $a_{jW}$ | 3 | 3 | 7 | 5 | 5 | 3 | 1 | 3 | 3 | | | |
| SP4 | X=4 | $a_{Bj}$ | 7 | 5 | 3 | 5 | 5 | 3 | 3 | 1 | - | 0.1905 | 0.3251 | Acceptable |
| | | $a_{jW}$ | 1 | 3 | 5 | 2 | 3 | 3 | 3 | 7 | - | | | |
| SP5 | X=5 | $a_{Bj}$ | 3 | 1 | 7 | 3 | 4 | 3 | 5 | - | - | 0.1905 | 0.3144 | Acceptable |
| | | $a_{jW}$ | 4 | 7 | 1 | 3 | 3 | 5 | 3 | - | - | | | |

Subsequently, each of the subproblems was modeled and solved using the preference data obtained from Table 6 and based on Model (1) in the LINGO software, and the initial weights of the factors were calculated. To ensure the reliability of the obtained results, the $CR^O$ values were computed and compared with the acceptable threshold values extracted from Table (3) (considering the number of criteria and the value of $a_{BW}$), as presented in Table (7). The



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results indicate that the solutions obtained for all five subproblems are acceptable and consistent.

**Table 7** $CR^O$ consistency analysis of the case study subproblems

| Sub-problems | $\xi^*$ | CI | $a_{BW}$ | number of criteria | $CR^O$ | CRT | Result |
|---|---|---|---|---|---|---|---|
| SP1 | 0.1926 | 1.63 | 4 | 4 | 0.1181 | 0.2352 | Acceptable |
| SP2 | 1.2583 | 3.73 | 7 | 5 | 0.3374 | 0.3734 | Acceptable |
| SP3 | 1.0000 | 3.73 | 7 | 9 | 0.2681 | 0.4298 | Acceptable |
| SP4 | 1.0000 | 3.73 | 7 | 8 | 0.2681 | 0.4108 | Acceptable |
| SP5 | 1.0000 | 3.73 | 7 | 7 | 0.2681 | 0.4035 | Acceptable |

Subsequently, since the initial weights of all factors had been calculated, the final weights of each factor were determined as presented in Table 8.

**Table 8** Weights of factors affecting the improvement of human resource productivity using the BWM–BSC approach in the Fars combined cycle power plant

| Final Weight | Initial Weight | Factors Affecting Human Resource Productivity | Weight | Perspective |
|---|---|---|---|---|
| 0.1885 | 0.3942 | Appropriate salary and wage system ($C_{2.1}$) | 0.4783 | Financial Perspective ($C_{1.1}$) |
| 0.1083 | 0.2264 | Timely payments ($C_{2.2}$) | | |
| 0.1082 | 0.2263 | Implementation of performance-based payment system ($C_{2.3}$) | | |
| 0.0228 | 0.0477 | Prevention of resource waste ($C_{2.4}$) | | |
| 0.0504 | 0.1054 | Provision of welfare and service facilities ($C_{2.5}$) | | |
| 0.0093 | 0.0741 | Adequate tools and equipment ($C_{3.1}$) | 0.1256 | Customer Perspective ($C_{1.2}$) |
| 0.0093 | 0.0741 | Clear communication between managers and employees ($C_{3.2}$) | | |
| 0.0372 | 0.2963 | Work ethics, commitment, and responsibility of employees ($C_{3.3}$) | | |
| 0.0186 | 0.1481 | Job satisfaction ($C_{3.4}$) | | |
| 0.0186 | 0.1481 | Fairness in work conditions ($C_{3.5}$) | | |
| 0.0093 | 0.0741 | Alignment between personal interests, skills, and job ($C_{3.6}$) | | |
| 0.0047 | 0.0370 | Friendly atmosphere among employees ($C_{3.7}$) | | |
| 0.0093 | 0.0741 | Safety and comfort in the work environment ($C_{3.8}$) | | |
| 0.0093 | 0.0741 | Physical work environment conditions ($C_{3.9}$) | | |
| 0.0059 | 0.0395 | Job rotation ($C_{4.1}$) | 0.1498 | Internal Processes Perspective ($C_{1.3}$) |
| 0.0118 | 0.0789 | Competency-based employee promotion system ($C_{4.2}$) | | |
| 0.0237 | 0.1579 | Non-discrimination and fairness among employees ($C_{4.3}$) | | |
| 0.0079 | 0.0527 | Establishment of a succession system among employees ($C_{4.4}$) | | |
| 0.0118 | 0.0789 | Job security ($C_{4.5}$) | | |
| 0.0177 | 0.1184 | Designing and implementing appropriate reward and punishment mechanisms ($C_{4.6}$) | | |
| 0.0237 | 0.1579 | Proper and logical distribution of human resources across departments ($C_{4.7}$) | | |
| 0.0473 | 0.3158 | Attention to employees' needs to increase motivation ($C_{4.8}$) | | |
| 0.0406 | 0.1646 | Management and leadership style ($C_{5.1}$) | 0.2463 | Learning and Growth Perspective ($C_{1.4}$) |
| 0.0812 | 0.3296 | In-service training ($C_{5.2}$) | | |
| 0.0101 | 0.0412 | Relevant education ($C_{5.3}$) | | |
| 0.0265 | 0.1075 | Work experience ($C_{5.4}$) | | |
| 0.0271 | 0.1098 | Creativity and innovation ($C_{5.5}$) | | |
| 0.0406 | 0.1648 | Sufficient skills and expertise of employees ($C_{5.6}$) | | |
| 0.0203 | 0.0824 | Teamwork and collaborative spirit ($C_{5.7}$) | | |


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The results indicate that, respectively, the financial, learning and growth, internal processes, and customer perspectives have the greatest impact on improving human resource productivity in the studied power plant. Furthermore, within the financial perspective, the existence of an appropriate salary and wage payment system; within the learning and growth perspective, in-service training; within the internal processes perspective, attention to employees' needs to enhance motivation; and within the customer perspective, employees' work ethic, commitment, and sense of responsibility were identified as the most influential factors in improving human resource productivity in the Fars Combined Cycle Power Plant.

Among the 29 identified factors, the five most important factors are, in order: the existence of an appropriate salary and wage payment system, in-service training, attention to employees' needs to enhance motivation, employees' work ethic, commitment, and sense of responsibility, and timely payment of wages and benefits. Notably, two of these five key factors in the studied power plant belong to the financial perspective.

## 6 Discussion

In this section, the findings of the present study are compared with the results of several similar studies. Consistent with the study by Sadeghi et al. [10], the financial perspective was identified as the most important perspective in improving human resource productivity. Moreover, in line with the findings of Sarwar and Sheikh [36], financial issues and wage-related factors were recognized as among the most influential determinants of human resource productivity. These results highlight the critical role of the financial perspective and financial incentives in enhancing human resource productivity.

Furthermore, according to the findings of Joudaki and Hasanpour [30], the appropriateness of salary levels and organizational payments was identified as the most important factor in improving employee productivity in the National Iranian Standards Organization. Similarly, in the present study, two out of the five most significant factors affecting human resource productivity in the studied power plant belong to the financial perspective, namely the existence of an appropriate salary and wage payment system and the timeliness of payments.

Additionally, consistent with the study conducted by Tekin et al. [37], organizational commitment and employees' commitment and sense of responsibility were identified as key factors contributing to the improvement of human resource productivity in the present research.

Overall, the present study contributes to the literature by integrating the BSC framework with a trustable group BWM approach, systematically identifying and prioritizing human resource productivity factors in a real-world industrial setting. This integration provides both theoretical insights and practical guidance for managers to effectively enhance human resource productivity. Moreover, the study demonstrates how these factors are appropriately linked to organizational strategies and vision, and it is effectively implemented in an industrial environment, specifically in a thermal power plant. By highlighting the connection between productivity factors and organizational strategy, this study not only reinforces the importance of strategic alignment in human resource management but also offers actionable recommendations for practitioners to improve performance in industrial contexts.



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## 7 Conclusion

Based on the findings of this study, the present research systematically identified and prioritized the key factors affecting human resource productivity in a thermal power plant, providing both theoretical insights and practical guidance for managers. The integration of the BSC framework with a trustable group BWM ensures that the prioritized factors are reliable and aligned with organizational strategy. The study emphasizes the importance of focusing on the financial and learning & growth perspectives as the most influential dimensions in enhancing human resource productivity. Furthermore, the results highlight critical managerial considerations, such as establishing an appropriate salary and wage payment system, implementing in-service training programs, addressing employees' motivational needs, fostering work ethic and commitment, and ensuring the timeliness of payments.

For future research, it is recommended to employ other MADM techniques, consider uncertainty in decision-making and data collection processes, utilize group decision-making approaches, and conduct case studies in other related industries to further identify and analyze factors contributing to the improvement of human resource productivity.

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