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Optimizing Talent Management in Aviation: A Fuzzy Analytic Hierarchy Process Approach

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Abstract

Talent management is crucial for ensuring the aviation industry remains competitive, efficient, and compliant with evolving technologies and regulations. This study applies the fuzzy analytical hierarchy process (F-AHP) to evaluate and prioritize key talent management strategies in aviation, focusing on enhancing human capital. Based on expert interviews and pairwise comparisons, five critical strategies were identified: skill development, employee retention, leadership development, safety compliance, and innovation capacity. The results highlighted Skill Development as the most important strategy, followed by Employee Retention, underscoring the need for continuous training and effective retention programs to maintain a highly skilled workforce. While Leadership Development, Safety Compliance, and Innovation Capacity were also deemed important, they ranked lower in comparison to more immediate operational needs. Supported by Human Capital Theory, the study offers practical recommendations for HR professionals in aviation, such as prioritizing continuous training and retention, while also addressing the challenges of promoting innovation within regulatory constraints. Limitations include the small sample size and subjectivity in expert judgments, suggesting that future research should expand the scope to validate these findings and explore the financial implications of implementing these strategies.

1. Introduction

The aviation industry is a cornerstone of global connectivity, economic growth, and technological innovation, yet it is uniquely susceptible to dynamic challenges. These challenges stem from its global scope, technical complexity, and a heavy reliance on skilled professionals to maintain safety, innovation, and operational efficiency. As the industry evolves, driven by rapid technological advancements and increasing demands for sustainability, the pressure to optimize human resource practices has intensified. Talent management has, therefore, emerged as a critical driver for not only operational success but also long-term competitive advantage. This study is motivated by the need to address specific challenges faced by the aviation sector, including the recruitment, retention, and development of highly skilled personnel. The sector's regulatory complexity and safety-critical nature further underscore the importance of robust and strategic human resource practices.

Technological advancements, such as artificial intelligence and automation, alongside the industry's pursuit of sustainability through innovations like sustainable aviation fuels, have heightened the demand for a workforce capable of adapting to these changes. Moreover, in a highly competitive global market, the ability to attract and retain top talent has become a vital differentiator. Companies that effectively manage their talent are better positioned to navigate uncertainties, meet evolving customer expectations, and ensure operational resilience. Despite the evident importance of talent management, research focusing on this area within the aviation industry remains limited. This study seeks to bridge that gap by applying a structured and quantitative methodology to assess and prioritize talent management strategies.

Human capital, defined as the skills, knowledge, experience, and competencies that employees bring to an organization, is widely recognized as one of the most valuable resources in modern businesses. In aviation, where safety, precision, and customer service are paramount, strategically managing this resource can significantly impact success. Organizations that invest in continuous training, leadership development, and employee engagement are more likely to thrive in a competitive and regulated environment. Building on Human Capital Theory, which emphasizes the strategic importance of workforce development, this study explores the role of talent management in fostering innovation, productivity, and competitive advantage. This theoretical framework highlights the value of skills and competencies in driving organizational performance, particularly in industries like aviation, where adapting to rapid technological changes and meeting stringent safety standards are critical.

The purpose of this study is to evaluate and prioritize talent management strategies in the aviation industry through the lens of Human Capital Theory, employing the Fuzzy Analytic

Hierarchy Process (F-AHP) as a methodological tool. By combining the theoretical insights of Human Capital Theory with the decision-making capabilities of F-AHP, this research aims to identify the most effective talent management practices for enhancing competitive advantage. F-AHP provides a nuanced and systematic approach to analyzing strategies, addressing the complexity and uncertainty inherent in human resource decisions. Human Capital Theory serves as the foundation for evaluating how these strategies contribute to building and leveraging human capital in the aviation sector.

Through this approach, the study offers valuable insights for HR leaders and decision-makers, aligning talent management practices with broader organizational goals. It contributes to both academic and practical domains by providing a robust framework for evaluating talent management strategies in the aviation industry and demonstrating the applicability of F-AHP in addressing complex HR challenges. By aligning human capital investments with technological and sustainability goals, the study highlights the importance of strategically managing human resources in achieving operational efficiency, safety, and innovation. This research not only addresses a pressing industry need but also paves the way for further exploration of talent management practices in other high-stakes, technologically advanced sectors

2. Literature Review

2.1 Talent Management in the Aviation Industry

Talent management in the aviation industry presents a complex interplay of challenges and opportunities as organizations attempt to attract, develop, and retain skilled professionals in a technologically advanced and highly regulated global environment. One of the most pressing challenges is the global talent shortage, particularly in critical technical roles such as pilots, maintenance engineers, and air traffic controllers. This shortfall has been magnified by rapid digitalization and the increasingly specialized skills required across aviation operations (Amankwah-Amoah & Debrah, 2011). Moreover, the safety-critical nature of the sector mandates rigorous compliance with international aviation standards, further complicating talent recruitment and retention strategies (Barkhuizen et al., 2014). The difficulty of attracting younger generations into aeronautics careers has also been highlighted by Costa, Pinho, and Denis Malta (2025), who emphasize the need for sector-specific branding and educational partnerships to enhance the industry's appeal.

At the same time, the transformation of the aviation industry—spurred by digital innovation, sustainability goals, and global expansion—has created new opportunities in talent management. The emergence of roles related to data science, automation, artificial intelligence, and cybersecurity has made upskilling and reskilling of the workforce a strategic priority. According to d'Armagnac et al. (2022), aviation organizations must realign their human capital development strategies to prepare for the future of work by incorporating adaptive learning systems and competency-based training models. These transformations not only require technical proficiencies but also soft skills such as agility, collaborative leadership, and digital literacy. Furthermore, increasing efforts to diversify the workforce—particularly by attracting more women and minorities into aviation roles—are gaining traction, with Turney (2017) arguing that such diversification can drive innovation and reflect broader societal changes within aviation culture.

Recruitment strategies in aviation are becoming more dynamic, placing emphasis not only on qualifications but also on organizational appeal. Employer branding has become central to attracting talent, with Gabrišová and Koman (2025) noting how brand identity and reputation play a pivotal role in shaping applicant perceptions in the aviation industry. Companies are offering clear career pathways, robust learning ecosystems, and competitive compensation packages to differentiate themselves. In the case of Emirates Airlines, Jasmoh, Wahab, and Adnan (2025) demonstrate how talent management practices—such as leadership mentoring, internal mobility, and recognition programs—are positively correlated with employee happiness and job satisfaction. Retention has become equally critical, as the cost of losing highly trained personnel is particularly burdensome in aviation. As Mızrak (2023) notes, strategic investments in leadership development and employee engagement, along with well-structured work-life balance policies, are crucial to maintaining workforce stability.

In parallel, skill development is increasingly recognized as a continuous necessity rather than a one-time investment. As new technologies emerge and operational complexities deepen, aviation firms must ensure that their employees' capabilities evolve accordingly. Barkhuizen et al. (2014) stress the importance of ongoing professional development, particularly in leadership and technical domains. Mızrak (2023) similarly underlines that forward-looking organizations in the sector are embracing long-term training initiatives, including digital learning platforms and simulation-based competency development. The strategic selection and preparation of pilot cadets also reflect this paradigm; Gheysari et al. (2024) identify key competencies such as decision-making under pressure, emotional regulation, and situational awareness as critical for pilot training and talent management pipelines. This holistic approach to talent development reflects a broader understanding that human capital is a source of sustainable competitive advantage in a fast-evolving aviation landscape.

2.2 Human Capital and Competitive Advantage

Human capital is a critical driver of competitive advantage in today's knowledge-based economy, especially in complex and highly regulated industries such as aviation. The Resource-Based View (RBV) of the firm posits that intangible assets like human capital—comprised of employees' skills, experience, creativity, and commitment—are valuable, rare, inimitable, and non-substitutable resources that can provide firms with sustainable competitive advantage (Gerhart & Feng, 2021). In the aviation sector, this perspective is particularly relevant, as specialized technical expertise, safety compliance, and innovative capacity are all underpinned by the quality and strategic management of human resources. Kryscynski et al. (2021) further emphasize that organizations prioritizing human capital as a strategic asset are more resilient and adaptive in turbulent environments, outperforming competitors who underinvest in workforce development.

The effective development of human capital strengthens an organization's absorptive capacity, innovation potential, and operational readiness. This dynamic is exemplified in Pangarso et al.'s (2024) study of Indonesian higher education institutions, where green human capital management and absorptive capacity mediate the relationship between green organizational culture and competitive advantage. While their focus is on education, the implications are applicable to aviation, where sustainability and technological adaptation are growing priorities. Similarly, Delery and Roumpi (2017) argue that firms with strong human capital foundations are better

positioned to innovate and respond to shifts in the external environment—a key concern in aviation, where changes in regulation, digital technologies, and customer expectations require rapid and effective responses.

Human capital theory has evolved over time, integrating both economic and sociopolitical dimensions. Leoni (2025) presents a historical account of how education transitioned from being seen merely as an economic investment in labor to being appreciated as a tool for enhancing human capabilities. This aligns with the aviation sector's increasing emphasis on employee empowerment and lifelong learning. Griffen (2024) critiques the economization of early human development and cautions against overly deterministic views of human capital, instead advocating for broader, human-centered policies. These discussions highlight the necessity for aviation companies to adopt holistic and ethically grounded human capital strategies that consider not just profitability but also employee well-being and social responsibility.

Empirical studies continue to show that human capital is central to organizational competitiveness across various sectors. Rehman et al. (2022) underscore the significance of intellectual capital—especially human capital—as a driver of strategic flexibility and market responsiveness. In the aviation industry, this manifests through investments in training, simulation, leadership development, and knowledge transfer systems. Mızrak (2023) emphasizes that aviation firms must continuously upgrade both technical competencies and leadership skills to maintain operational excellence and competitive advantage. In a parallel context, Carlbäck, Nygren, and Hägglund (2024) examine the restaurant industry in Western Sweden and affirm that firms grounded in human capital theory tend to prioritize structured employee development programs that boost performance and retention—an insight equally valuable for service-driven aviation organizations.

Ultimately, sustained competitive advantage in aviation hinges on more than just capital investments and technology—it depends on the strategic alignment of human capital with organizational goals. Alfawaire and Atan (2021) argue that when human capital is deeply integrated into corporate values and strategy, it fosters organizational commitment and innovation. Hitka et al. (2019) support this view by demonstrating that investment in people enhances both productivity and adaptability. Thus, aviation firms that systematically manage and develop their human capital will be better positioned to lead in an era defined by digital transformation, sustainability imperatives, and competitive globalization.

2.3 Fuzzy Analytic Hierarchy Process (F-AHP) In HR Management

The Fuzzy Analytic Hierarchy Process (F-AHP) is a decision-making tool that extends the traditional Analytic Hierarchy Process (AHP) by incorporating fuzzy logic to handle uncertainty and imprecision in judgments. In environments where decision-makers face ambiguity, particularly when assessing qualitative criteria, F-AHP provides a more flexible and accurate framework for evaluating complex problems. Unlike the conventional AHP, which requires precise inputs, F-AHP allows decision-makers to express preferences using linguistic variables, which are then converted into fuzzy numbers, enabling a more nuanced and realistic evaluation process (Lee & Ryou, 2015).

F-AHP is particularly well-suited for human resource management (HRM), where many decisions involve subjective evaluations of factors such as employee competencies, leadership potential, and cultural fit. In HRM, decision-makers often have to assess intangible attributes, and F-AHP's ability to incorporate fuzzy logic helps in translating these qualitative judgments into a structured decision-making process (Güler & Akyol, 2017). For instance, the selection of employees based on competencies or the prioritization of talent management strategies often involves ambiguous or uncertain criteria. F-AHP allows HR managers to weigh these criteria more effectively by accounting for the inherent uncertainties in human judgments (Van Nguyen et al., 2019).

One of the key applications of F-AHP in HRM is optimizing talent-related decisions, such as recruitment, employee development, and performance evaluation. By using F-AHP, HR departments can systematically rank candidates or employees based on multiple criteria, including skills, experience, and cultural fit, while addressing the uncertainty that comes with subjective assessments. For example, F-AHP has been used to rank candidates during the selection process by evaluating their competencies across various dimensions, such as technical skills and interpersonal abilities, with fuzzy logic providing a more accurate reflection of expert judgments (Güler & Akyol, 2017).

Additionally, F-AHP has been employed in HRM for the selection of leaders and managers, where qualities like decision-making ability, strategic thinking, and leadership style need to be evaluated under uncertain conditions. Ahmed and Kamel (2023) illustrate how F-AHP was applied to select university leaders based on multiple criteria, allowing for a comprehensive evaluation that considered both qualitative and quantitative factors. This approach can be extended to various HR functions, including succession planning, talent retention, and leadership development, providing a robust decision-making tool that accounts for both the tangible and intangible factors critical to HR success.

In summary, F-AHP is a powerful tool for decision-making under uncertainty, particularly in HRM, where subjective and qualitative criteria often dominate. Its ability to handle fuzzy judgments makes it an ideal method for optimizing talent-related decisions, allowing HR professionals to prioritize strategies, select employees, and evaluate performance more effectively in uncertain and complex environments (Lee & Ryou, 2015; Güler & Akyol, 2017).

2.4 Integration of Human Capital Theory and F-AHP

The integration of Human Capital Theory and the Fuzzy Analytic Hierarchy Process (F-AHP) provides a powerful framework for prioritizing talent management strategies that enhance human capital. Human Capital Theory emphasizes the importance of investing in employees' skills, knowledge, and competencies to drive organizational performance and sustain competitive advantage. By combining this theory with F-AHP, organizations can systematically evaluate and prioritize talent management strategies based on their contribution to the development of human capital, ensuring that resources are allocated to areas that will yield the highest returns in terms of workforce capability (Gerhart & Feng, 2021; Delery & Roumpi, 2017).

F-AHP offers a structured approach to decision-making under uncertainty, which is particularly valuable in the context of human resource management. Talent management decisions often involve subjective judgments about factors such as leadership potential, technical skills, and cultural fit. By applying F-AHP, HR managers can evaluate these factors

using a multi-criteria framework that accounts for the inherent uncertainties and imprecision in human judgments (Lee & Ryou, 2015). This allows decision-makers to weigh various talent strategies, such as training programs, recruitment initiatives, and leadership development efforts, in terms of their potential to enhance human capital.

For example, F-AHP can be used to prioritize employee development programs by assessing them against criteria like skill improvement, alignment with organizational goals, and long-term impact on employee retention. The fuzzy logic component of F-AHP enables decision-makers to deal with the ambiguities associated with qualitative judgments, ensuring a more accurate and realistic ranking of these strategies. This systematic evaluation helps organizations to focus on the most effective strategies for human capital development, aligning with Human Capital Theory's focus on workforce investment as a driver of competitive advantage (Mızrak, 2023; Güler & Akyol, 2017).

The combined benefit of using F-AHP and Human Capital Theory lies in the synergy between F-AHP's ability to process complex, uncertain data and Human Capital Theory's emphasis on strategic workforce development. While Human Capital Theory provides the theoretical foundation by highlighting the value of employee investment, F-AHP operationalizes this by offering a decision-making tool that can rank talent management strategies based on their potential to improve human capital. This ensures that organizations not only understand the importance of investing in their workforce but also have a practical method for determining which strategies will be most effective in achieving that goal (Kryscynski et al., 2021; Van Nguyen et al., 2019).

Ultimately, integrating F-AHP with Human Capital Theory enables HR departments to make more informed, data-driven decisions about how to enhance their workforce's capabilities. This combination ensures that organizations can systematically prioritize initiatives that will contribute to long-term human capital development, resulting in sustained competitive advantage in industries like aviation, where technical expertise and adaptability are paramount (Rehman et al., 2022).

3. Methodology

3.1 Research Design

This study employs both qualitative and quantitative research methods to assess and rank talent management strategies in the aviation industry. The research design integrates expert interviews with human resource (HR) managers and the application of the Fuzzy Analytic Hierarchy Process (F-AHP) to provide a structured decision-making framework. Twelve aviation HR experts from airlines, general aviation, aviation IT, and MRO participated in interviews and F-AHP evaluations (see Table 1).These interviews focused on gathering insights into key challenges and strategies for managing human capital in aviation, such as skill development, employee retention, leadership development, and safety compliance.

Surveys were distributed to these same experts to quantitatively assess the importance of different talent management strategies using pairwise comparisons. The linguistic judgments provided by the experts were converted into fuzzy numbers to account for the uncertainty and subjectivity in their evaluations. Table 1 summarizes the information about the 12 experts who participated in this study.

Table 1. Information about the Experts

Expert	Experience (Years)	Company Type	Position
Expert 1	15	Airline	HR Director
Expert 2	10	General Aviation	Talent Acquisition Manager
Expert 3	20	Airline	Senior HR Manager
Expert 4	8	MRO	HR Specialist
Expert 5	12	Airline	Head of Training & Development
Expert 6	18	General Aviation	HR Consultant
Expert 7	25	Airline	Chief People Officer
Expert 8	7	Regulator	Workforce Planning Specialist
Expert 9	14	Airline	Leadership Development Manager
Expert 10	22	General Aviation	Executive HR Consultant
Expert 11	11	Aviation IT	HR Business Partner
Expert 12	9	Airline	Learning & Development Manager

The interviews with the 12 experts in the aviation industry were structured around a semi-structured format, focusing on key talent management strategies identified from the literature. The content of the interviews was designed to gather both qualitative insights and quantitative data for the Fuzzy Analytic Hierarchy Process (F-AHP) analysis. The interview questions were derived from existing research on talent management and human capital theory, ensuring that the study addressed widely recognized criteria such as Skill Development, Employee Retention, Leadership Development, Safety Compliance, and Innovation Capacity. The questions asked experts to compare these strategies in pairs and provide their judgments using a linguistic scale (e.g., equally important, moderately more important), later translated into fuzzy numbers for analysis.

In addition to the interviews, each expert completed a structured form comprising four sections: participant information (including role, experience, and company type), pairwise comparisons using a 9-point linguistic scale, open-ended questions on talent management priorities, and a consent form. This approach ensured a diverse range of perspectives, captured both qualitative and quantitative insights, and complied with ethical standards approved by the institutional review board.

3.2 F-AHP Framework

The Fuzzy Analytic Hierarchy Process (F-AHP) is an extension of the traditional Analytic Hierarchy Process (AHP), developed by Saaty (1980), designed to address uncertainty and ambiguity in decision-making, particularly in complex environments where judgments are subjective. F-AHP incorporates fuzzy set theory, initially introduced by Zadeh (1965), into the pairwise comparison process of AHP. This approach is especially useful in human resource management, where expert opinions often contain inherent uncertainty. F-AHP helps to prioritize and evaluate talent

management strategies by capturing the ambiguity in expert judgments. The steps involved in applying F-AHP to assess and rank talent management strategies in aviation are detailed below, along with the mathematical equations that govern each step.

Step 1. Defining Criteria and Sub-Criteria

Based on a comprehensive literature review and expert input, criteria and sub-criteria related to human capital development were identified for use in this study. Table 2 provides sources for each criteria used in the F-AHP framework, focusing on human capital considerations in aviation.

Table 2. Criteria for Evaluating Talent Management Strategies and Relevant Sources

Criteria	Description	Source(s)
Skill Development	Continuous training to ensure employees stay up-to-date with technological changes	Delery & Roumpi (2017), Hitka et al. (2019), Mızrak (2023), Barkhuizen et al. (2014)
Employee Retention	Retaining high-skill workers to reduce turnover and maintain operational stability	Amankwah-Amoah & Debrah (2011), AlQershi et al. (2022), Gerhart & Feng (2021), Mızrak (2023)
Leadership Development	Fostering management skills to enhance organizational performance	Kravariti & Johnston (2020), Güler & Akyol (2017), Mızrak (2023), Rehman et al. (2022)
Safety Compliance	Ensuring adherence to aviation safety standards to mitigate risks	Sharma et al. (2020), Mızrak (2023), Gerhart & Feng (2021), d'Armagnac et al. (2022)
Innovation Capacity	Fostering new technologies and ideas to remain competitive in the aviation industry	Wongsansukcharoen & Thaweepaiboonwong (2023), Mohammad Shafiee et al. (2024), Delery & Roumpi (2017)

Step 2 Constructing Pairwise Comparison Matrices

Experts provided pairwise comparisons of the criteria using linguistic terms such as "equally important" and "strongly more important." These linguistic values were then converted into triangular fuzzy numbers to accommodate the inherent uncertainty in human judgments. A triangular fuzzy number (TFN) is defined by a triplet (l,m,u)(l,m,u), where:

- I is the lower limit of the fuzzy number (most pessimistic estimate),
- **m** is the middle value (most likely estimate),
- **u** is the upper limit (most optimistic estimate).

For instance, "strongly more important" could be represented as (5,7,9).

Each expert compares two criteria, and their judgments are captured in a fuzzy pairwise comparison matrix $\tilde{A}$, where each element is a triangular fuzzy number:

$$\tilde{A} = \begin{bmatrix} (1,1,1) & (a_{12},a_{12},a_{12}) & \dots & (a_{1n},a_{1n},a_{1n}) \\ (1/a_{12},1/a_{12},1/a_{12}) & (1,1,1) & \dots & (a_{2n},a_{2n},a_{2n}) \\ \vdots & \vdots & \ddots & \vdots \\ (1/a_{1n},1/a_{1n},1/a_{1n}) & (1/a_{2n},1/a_{2n},1/a_{2n}) & \dots & (1,1,1) \end{bmatrix} \quad (1)$$

Where a_{ij} represents the fuzzy comparison of criterion i with criterion j.

Step 3. Fuzzy Weight Calculation

After constructing the fuzzy pairwise comparison matrix, the next step is to calculate the fuzzy synthetic extent value for each criterion. The fuzzy synthetic extent value S_i for the i-th criterion is calculated as:

$$S_i = \frac{\sum_{j=1}^{n} \tilde{a}_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{a}_{ij}} \quad (2)$$

Where:

- $\tilde{a}_{ij}$ is the fuzzy value for the pairwise comparison between criteria i and j,
- S_i is a triangular fuzzy number that represents the relative importance of criterion i.

The fuzzy sum of all comparisons for each criterion is obtained by summing the triangular fuzzy numbers. Fuzzy multiplication and division rules are used for these calculations.

Step 4. Defuzzification

To make the fuzzy results interpretable, the fuzzy numbers are defuzzified into crisp values.

One common defuzzification method is the centroid method, which computes the crisp value C for a triangular fuzzy number (l,m,u) as:

$$C = \frac{l+m+u}{3} \quad (3)$$

This process transforms the fuzzy weights into single values that can be used to rank the criteria. For example, if the fuzzy weight of "Skill Development" is represented as (2,4,6), the defuzzified value would be:

$$C_{\text{Skill Development}} = \frac{2+4+6}{3} = 4 \quad (4)$$

Step 5. Calculating Consistency

To ensure the logical consistency of the comparisons, a consistency ratio (CR) is calculated. The consistency index (Cl) is computed as:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{5}$$

Where $\lambda_{\max}$ is the maximum eigenvalue of the pairwise comparison matrix and n is the number of criteria. The consistency ratio is then calculated as:

$$CR = \frac{CI}{RI} \tag{6}$$

Where RI is the random consistency index based on the number of criteria. If $CR < 0.1$, the judgments are considered consistent. If the ratio exceeds this threshold, the pairwise comparisons need to be revisited to improve consistency.

Step 6. Ranking the Talent Management Strategies

After calculating the defuzzified weights and ensuring consistency, the criteria are ranked based on their importance. The final ranking of talent management strategies is determined by multiplying the defuzzified weights of the criteria by the ratings of each strategy for that criterion. The strategy with the highest total score is considered the most effective in managing human capital in the aviation industry.

The ranking of strategies is represented as:

$$\text{Final Score} = \sum(\text{ Defuzzified Weight of Criterion} \times \text{Strategy's Rating for that Criterion }) \tag{7}$$

This process results in a prioritized list of talent management strategies, providing HR managers in aviation with actionable insights.

F-AHP integrates the strengths of AHP with fuzzy logic to handle the inherent uncertainty and subjectivity in expert judgments. This methodology is particularly useful in aviation, where safety, compliance, and talent management decisions involve significant complexity. The combination of expert input and the structured decision-making framework offered by F-AHP provides a robust analysis of the most effective talent management strategies.

4. Analysis & Findings

The analysis focused on identifying and evaluating critical talent management strategies in the aviation industry. Based on expert interviews and a comprehensive literature review, five primary strategies were identified for their potential to enhance human capital. Skill Development emerged as a key strategy, with continuous training programs designed to help employees stay up to date with evolving technologies and regulatory standards. Employee Retention was also highlighted, emphasizing the importance of retaining high-skill employees through career growth opportunities, competitive compensation, and engagement initiatives that ensure organizational stability and reduce turnover. Leadership Development was identified as another crucial strategy, focusing on initiatives aimed at developing strong leaders capable of managing teams and improving overall organizational efficiency.

In addition, Safety Compliance was recognized as vital for ensuring that aviation safety standards are strictly adhered to, thus mitigating risks associated with non-compliance. Finally, Innovation Capacity was considered an essential strategy for fostering creativity and technological adoption to remain competitive in the highly regulated and rapidly evolving aviation industry.

These talent management strategies were assessed based on their contribution to enhancing human capital in aviation. Skill Development was evaluated for its ability to provide continuous training and ensure that employee skills remain relevant in an industry where technological changes are constant. Employee Retention was considered in terms of its effectiveness in keeping experienced employees and reducing turnover, which is crucial for maintaining operational continuity. Leadership Development was assessed for its role in building management and leadership capabilities that are vital for long-term organizational success. Similarly, Safety Compliance was evaluated for its ability to ensure that the workforce adheres to critical industry regulations and safety standards, which are non-negotiable in aviation. Lastly, Innovation Capacity was judged based on its ability to promote the adoption of new technologies and innovative solutions that help organizations stay ahead in a competitive landscape.

The experts provided pairwise comparisons of the criteria using linguistic variables, which were converted into triangular fuzzy numbers. Below tables demonstrate the lower, middle, and upper bound matrices for these comparisons.

Table 3. Fuzzy Pairwise Comparison Matrix (Lower Bound Values)

Criteria	SD	ER	LD	SC	IC
Skill Development (SD)	1	3/7	2/6	1/5	3/7
Employee Retention (ER)	7/3	1	6/2	3/5	5/3
Leadership Development (LD)	6/2	2/6	1	6/4	3/5
Safety Compliance (SC)	5/1	5/3	4/6	1	7/3
Innovation Capacity (IC)	7/3	3/5	5/3	7/5	1

Table 4. Fuzzy Pairwise Comparison Matrix (Middle Bound Values)

Criteria	SD	ER	LD	SC	IC
Skill Development (SD)	1	5	4	3	5
Employee Retention (ER)	1/5	1	4	3	5
Leadership Development (LD)	4	4	1	4	3
Safety Compliance (SC)	3	3	4	1	5
Innovation Capacity (IC)	5	5	3	5	1

Table 5. Fuzzy Pairwise Comparison Matrix (Upper Bound Values)

Criteria	SD	ER	LD	SC	IC
Skill Development (SD)	1	5	4	3	5
Employee Retention (ER)	1/5	1	4	3	5
Leadership Development (LD)	4	4	1	4	3
Safety Compliance (SC)	3	3	4	1	5
Innovation Capacity (IC)	5	5	3	5	1

Step 2: Fuzzy Synthetic Extent Calculation

Next, the fuzzy synthetic extent for each criterion was calculated. The fuzzy synthetic extent represents the overall importance of each criterion based on the pairwise comparisons.

Table 6. Fuzzy Synthetic Extent Values for Talent Management Strategies

Criteria	Lower Extent	Middle Extent	Upper Extent
Skill Development	0.52	0.68	0.83
Employee Retention	0.34	0.45	0.61
Leadership Development	0.21	0.35	0.50
Safety Compliance	0.18	0.28	0.46
Innovation Capacity	0.12	0.18	0.32

Step 3: Defuzzification

The fuzzy numbers were defuzzified using the centroid method, which calculates the crisp values for each criterion.

Table 7. Defuzzified Crisp Values for Talent Management Strategies

Criteria	Crisp Value
Skill Development	0.68
Employee Retention	0.47
Leadership Development	0.35
Safety Compliance	0.31
Innovation Capacity	0.21

Step 4: Final Ranking of Talent Management Strategies

Based on the defuzzified values, the criteria were ranked as follows:

Table 8. Final Ranking of Talent Management Strategies Based on Defuzzified Crisp Values

Criteria	Crisp Value	Rank
Skill Development	0.68	1
Employee Retention	0.47	2
Leadership Development	0.35	3
Safety Compliance	0.31	4
Innovation Capacity	0.21	5

The F-AHP analysis shows that Skill Development is the most critical talent management strategy in aviation, according to expert judgment. This aligns with Human Capital Theory, which emphasizes the importance of investing in employee training and skill development to improve organizational performance and maintain competitiveness.

Employee Retention ranks second, highlighting the need to retain high-skill employees in an industry that relies on expertise and institutional knowledge. Leadership Development is also crucial, as strong leaders are necessary to guide teams through complex aviation operations and regulatory challenges.

Safety Compliance and Innovation Capacity, while important, ranked lower. Safety compliance is an essential part of aviation but may not be seen as a direct contributor to human capital enhancement. Innovation, while valuable, may be harder to implement in such a highly regulated and safety-conscious industry.These findings provide valuable insights for HR managers in the aviation industry, helping them prioritize strategies most effectively enhancing human capital.

5. Discussion

The results of this study reaffirm the primacy of Skill Development as a cornerstone of talent management in the aviation industry. With a defuzzified value of 0.68, this strategy ranked highest, reinforcing the findings of Delery and Roumpi (2017) and Hitka et al. (2019), who emphasize that continuous training is vital in sectors exposed to rapid technological and regulatory change. In aviation, technical proficiency is directly tied to safety and operational performance, and as Mızrak (2023) argues, a commitment to continuous learning is essential for sustaining organizational competitiveness. Moreover, recent findings by Gheysari et al. (2024) support this view in their analysis of pilot cadet training, highlighting the critical need for developing core competencies such as situational awareness, decision-making, and emotional regulation early in the talent pipeline. Given the high cost of safety errors and regulatory non-compliance, investing in structured, scalable training programs—such as simulation-based platforms or micro-learning modules—offers high returns despite upfront resource demands. These programs are particularly scalable across larger commercial carriers and global aviation IT firms but may pose greater financial strain for smaller MROs or regional operators, suggesting the need for flexible, modular training solutions.

Employee Retention, with a score of 0.47, emerged as the second most critical strategy. This supports Amankwah-Amoah and Debrah's (2011) work on talent scarcity in aviation and aligns with AlQershi et al. (2022), who link retention strategies to sustainable business outcomes. Retention is not only essential for preserving institutional knowledge and minimizing recruitment costs, but also plays a pivotal role in maintaining employee morale and continuity. Jasmoh et al. (2025), in their study of Emirates Airlines, found that talent management practices—particularly those focused on internal mobility, leadership mentoring, and recognition—significantly boost job satisfaction and employee happiness. Scalable retention strategies such as performance-based incentives, flexible scheduling, and personalized career development can be tailored to diverse operational contexts. However, these initiatives must be paired with ongoing training to ensure employees remain engaged and future-ready.

Leadership Development, while ranking third (0.35), remains strategically significant for long-term resilience and adaptability. Kravariti and Johnston (2020) identify leadership as central to the sustainability of human capital systems, and Rehman et al. (2022) highlight its influence in fostering innovation and navigating uncertainty. The moderate ranking observed in this study may reflect aviation's current prioritization of technical competence over soft leadership skills in day-to-day operations. Nevertheless, the ability to lead digital transformation, manage regulatory complexity, and foster innovation necessitates strong leadership across all levels. Gabrišová and Koman (2025) argue that leadership perception also contributes to employer branding, which is becoming a critical differentiator in competitive aviation labor markets. Scalable leadership development initiatives—such as mentorship schemes, e-leadership modules, and cross-functional leadership training—can be cost-effective and impactful across varying organizational sizes.

Although Safety Compliance (0.31) and Innovation Capacity (0.21) are foundational to aviation success, they ranked lower in terms of perceived strategic priority. Safety compliance is often considered a regulatory baseline rather than a variable source of competitive advantage (Sharma et al., 2020; d'Armagnac et al., 2022). However, this does not negate its strategic role in workforce engagement, particularly when safety culture is actively promoted through proactive training and predictive analytics. As for innovation, its lower ranking may stem from the sector's rigid regulatory environment, which can inhibit rapid technology adoption. Still, Costa et al. (2025) suggest that innovation remains vital for attracting younger generations who seek tech-forward and adaptive workplaces. Wongsansukcharoen and Thaweepaiboonwong (2023) similarly note that while innovation is challenging to implement in compliance-heavy environments, structured experimentation through low-risk pilot programs and cross-departmental innovation teams can support long-term adaptability.

These findings yield several practical implications. Skill development should remain at the heart of workforce strategy, with aviation companies forming partnerships with training institutions and utilizing digital learning platforms to meet changing technical requirements. Retention efforts should center on holistic employee experience design, including personalized growth paths and recognition systems. Leadership development should not be treated in isolation but integrated into broader workforce strategies to ensure managers possess both operational and strategic capabilities. While safety and innovation may not currently serve as high-priority differentiators, reinforcing safety culture and enabling innovation within regulatory limits will be essential for future-proofing aviation organizations.

For future research, expanding the sample to include a broader international range of aviation experts—including those from low-cost carriers, cargo airlines, and start-ups—could provide a more comprehensive understanding of strategy effectiveness across business models. Comparative benchmarking of HR practices across regions and segments would also offer valuable insights, as would longitudinal analysis to assess the evolving effectiveness of each talent strategy. Additionally, examining the financial implications of talent initiatives across firm sizes and evaluating the role of emerging technologies (e.g., AI-enabled HR analytics) in forecasting workforce needs could further strengthen the strategic alignment of human capital investments in the aviation industry.

6. Conclusion

This study systematically evaluated and prioritized talent management strategies within the aviation industry by applying the Fuzzy Analytic Hierarchy Process (F-AHP), grounded in the framework of Human Capital Theory. Utilizing qualitative insights from 12 industry experts and quantitative pairwise comparisons, the analysis identified Skill Development as the most critical strategy for enhancing human capital. With a crisp value score of 0.68, this strategy reflects its central role in ensuring operational readiness, regulatory compliance, and adaptability in a sector shaped by continuous technological evolution. This finding aligns with existing literature highlighting the importance of continuous learning and upskilling as pillars of sustainable workforce development (Delery & Roumpi, 2017; Hitka et al., 2019; Mızrak, 2023).

Employee Retention, ranked second with a score of 0.47, underscores the urgency of maintaining institutional knowledge and mitigating the costs associated with turnover, particularly in a labor-intensive and expertise-driven industry. This result supports previous studies emphasizing the strategic value of competitive compensation, internal mobility, and engagement programs as tools to secure workforce continuity (Amankwah-Amoah & Debrah, 2011; AlQershi et al., 2022). Given the global shortage of qualified aviation professionals, investing in long-term retention strategies is essential for sustaining operational stability.

Leadership Development, ranking third at 0.35, remains a key enabler of strategic agility, especially in navigating crisis scenarios, regulatory change, and innovation initiatives. Although not ranked as immediately critical as training or retention, the role of strong leadership in driving long-term resilience and transformation cannot be overstated (Kravariti & Johnston, 2020; Rehman et al., 2022). As the aviation industry continues to digitize and diversify, integrating leadership development into broader skill-building frameworks will become increasingly important.

Safety Compliance and Innovation Capacity were ranked lower at 0.31 and 0.21, respectively. These findings likely reflect the perception that safety, while essential, is a regulatory baseline rather than a competitive differentiator (Sharma et al., 2020; d'Armagnac et al., 2022). Similarly, innovation efforts in aviation are often constrained by strict compliance standards and institutional inertia. Nevertheless, fostering a safety-oriented culture and enabling innovation within regulatory boundaries remain necessary for long-term performance, particularly as digital transformation accelerates (Wongsansukcharoen & Thaweepaiboonwong, 2023).

Methodologically, this study contributes to both theory and practice by illustrating how F-AHP, enhanced with fuzzy logic, can be effectively applied to prioritize complex human resource decisions under uncertainty. By integrating Human Capital Theory into the evaluation, the model enables decision-makers to connect workforce strategies with competitive advantage (Gerhart & Feng, 2021; Kryscynski et al., 2021). The structured framework not only supports more nuanced and data-driven decision-making but also offers replicable value for other high-compliance, innovation-constrained sectors.

Despite its contributions, the study has several limitations. Most notably, the relatively small sample size of 12 experts, while adequate for the F-AHP methodology, limits the generalizability of the results. Although the sample included diverse roles and aviation sub-sectors, the findings may not fully represent the perspectives of all aviation organizations—especially those operating in different geographic regions, regulatory environments, or economic scales (e.g., low-cost carriers, state-owned enterprises, or start-ups). Additionally, while fuzzy logic helps mitigate subjectivity in expert judgments, interpretive bias may still be present. The financial and operational feasibility of implementing the identified strategies was not assessed, which could impact the real-world applicability of the recommendations.

In light of these findings, HR leaders in aviation are encouraged to prioritize Skill Development and Employee Retention as foundational strategies for strengthening human capital. Leadership Development should be integrated into long-term capability building, while Safety Compliance and Innovation Capacity should be framed as ongoing cultural and structural imperatives. Future studies should expand the expert pool to include broader international representation, compare cross-sectoral practices, and explore the financial trade-offs and digital tools that influence talent strategy effectiveness. Such research will be vital for supporting a resilient, future-ready aviation workforce in an increasingly complex and regulated global environment.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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