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LEADERSHIP AND EMPLOYEE SATISFACTION: AN EMPIRICAL STUDY BASED ON FEATURE ANALYSIS WITH MACHINE LEARNING

Abstract:

Employee satisfaction is an important indicator of organizational success and leadership effectiveness. The aim of this study is to investigate employees' perceptions of leadership in organizations and to determine its influence on job satisfaction. The focus is on key leadership dimensions such as trust in the employer, fairness, communication, understanding of employees and autonomy at work. The research comprised a primary quantitative study conducted through an online survey of employees from different sectors using a standardized and structured questionnaire. A total of 120 responses were collected, of which 103 were valid for analysis. The data was analyzed using the Random Forest algorithm for machine learning, with the interpretation of features through SHAP values. Leadership was defined as a predictor variable, while job satisfaction was analyzed at two levels – as an overall dependent variable reflecting general employee satisfaction and as a dependent sub-variable providing insight into specific aspects of job satisfaction.

The results showed that variables relating to fairness, employee age and communication had the greatest impact on job satisfaction, while variables such as gender and education level had a significantly lower predictive value. The model achieved moderate recall (0.75) but lower overall accuracy (0.55) and a moderate F1 score (0.68), suggesting the need for further model optimization. The study highlights specific leadership aspects that significantly influence employee satisfaction. Based on the results, guidelines can be formulated for developing more effective organizational practices, with a focus on promoting fairness, clear and open communication, and building mutual trust in the workplace. In addition, further research and refinement of predictive models of employee satisfaction are recommended to improve the quality of organizational decision making and more accurately identify factors that contribute to positive work outcomes.

Keywords:

Leadership, Employee satisfaction, Predictive model, Random forest, SHAP analysis

JEL Classification: J28, O15

Introduction

In the modern business world, employee satisfaction as a key factor for organizational effectiveness directly depends on the quality of leadership, which shapes the work climate, fosters motivation and influences the perception of fairness, communication and autonomy in the workplace. Given the multidimensional nature of employee satisfaction, there is a need for the application of analytical tools that allow an in-depth analysis of the relationships between different aspects of leadership and satisfaction. In this context, the application of machine learning methods represents a contemporary approach that enables not only the development of predictive models, but also the interpretation of complex relationships between variables. Algorithms such as Random Forest, together with interpretative techniques such as SHAP values, provide a transparent insight into the model structure and allow the identification of key factors that influence the prediction results. The aim of this paper is to empirically investigate employee perceptions of leadership in organizations and analyze their impact on job satisfaction using a machine learning approach. Particular attention is paid to the identification of leadership dimensions that contribute most to a positive perception of the work environment and to the analysis of the limitations of the predictive model in relation to the generalization of the results. Based on the research conducted, the paper aims to formulate recommendations for the development of more effective organizational practices based on the principles of fairness, transparent communication and building mutual trust.

Theoretical framework and previous research

Job satisfaction is a broad concept that, as Riyanto et al. (2021) stated, cannot be described by a single definition. According to Wang (2024), job satisfaction refers to employees' attitudes towards their work, which includes their feelings, perceptions and evaluations of work. Similarly, Sjarifudin and Ali (2023) describe it as a subjective feeling of satisfaction or a positive feeling associated with the employee's perception of their work and the performance they deliver. Atobishi and Nosratabadi (2023) investigated the driving and limiting factors of employee satisfaction. Their study focused on remote work but was successful in demonstrating that the key drivers of employee satisfaction include job satisfaction itself, institutional and technical support and work-life balance. Employee satisfaction is increasingly becoming one of the fundamental drivers of employee wellbeing and sustainable development (Sypniewska et al., 2023). This is a complex topic that has been addressed by numerous studies. Although each of these studies attempts to define employee satisfaction in its own way, they all ultimately agree that it is a positive feeling associated with one's work. As Rogozińska-Pawelczyk and Olbrys (2023) note, job satisfaction is particularly important for countries where a free labor market is still developing. In these countries, employees are less and less connected to their employers and view them primarily through the lens of their own interests. Such a situation underscores the importance of researching this topic and investing resources so that companies can have a clear and realistic understanding of employees' feelings and perceptions. Satisfaction is a multidimensional concept that is influenced by employee attitudes and their level of satisfaction. Employees may be very satisfied with one aspect of their job while being very dissatisfied with other aspects. Hidayat et al (2022) also point out that employee satisfaction is an unstable variable that is influenced by employees' current feelings, events at work and personal perceptions. Riyanto et al. (2021) categorize the most common methods of classifying job satisfaction into intrinsic and extrinsic job satisfaction. Intrinsic motivation is defined as motivation that arises from the satisfaction of performing an activity itself (Novianti & Ramli, 2023). Intrinsic motivation represents a person's personal desire to achieve a goal. According

to Shafi et al. (2020), intrinsic motivation reflects employees' interest in achieving a goal solely for the sake of their own satisfaction. The same study shows that intrinsic motivation is one of the key factors in promoting employee creativity. Extrinsic motivation, on the other hand, comes from external sources. It can take the form of financial rewards or verbal praise. An extrinsically motivated employee performs tasks in order to receive something in return. Research shows a significant correlation between intrinsic and extrinsic motivation and the willingness of employees to participate and engage in their work. However, motivation is not the only factor that influences employee satisfaction. According to Voordt and Jensen (2021), although it should be the goal of every employer, a healthy work environment can be one of the deciding factors in employee satisfaction. A good work-life balance can significantly reduce feelings of burnout among employees and help maintain optimal levels of productivity, attendance and engagement (Hidayat et al., 2022). Employee satisfaction has an impact on work motivation, organizational behavior and communication with colleagues. Satisfied employees listen to the needs of their colleagues, are more likely to speak positively about their company and are aligned with the company's goals, vision and mission. Dissatisfied employees, on the other hand, are disconnected from the company's goals and mission. In their study, Neumeyer et al. (2023) emphasize that theoretical reviews show a significant correlation between the financial situation of a company and the amount of resources the company is willing to allocate to employee well-being. Although this relationship is still under-researched, theorists agree that such a link exists. In their study, they investigated how the personality traits of company leaders influence the negative impact of a company's financial situation. The hypothesis is that an extroverted CEO can increase employee satisfaction by promoting optimism and influencing the company culture, while an introverted CEO can have a positive impact by increasing the sense of security. The study showed that a poor financial situation can be mitigated if the director has two personality traits: high openness to experience and low conscientiousness. On the other hand, the opposite combination of these traits can be extremely detrimental to employee satisfaction.

Leading teams is a challenging task that is becoming increasingly dynamic as the business world grows and globalizes. The way a company is managed is crucial at every stage of its operations. Different leadership styles are used to lead employees and the current state of an company as well as its future development is a direct product of its leadership (Sulej & Iqbal, 2022). Leadership should fulfill business goals such as profit while motivating employees and encouraging them to reach their full potential in performing daily tasks and creative activities (Talajić et al., 2022). The authors highlight several characteristics of good leaders, such as active listening, excellent conflict management, decisiveness, strategic thinking and encouraging employee growth. They propose a framework for describing leadership which consists of four domains: environment, leadership, people and performance. Through their research, the authors have identified the strongest links within these four domains. They emphasize that management must always be aware that these areas influence each other and, when considered together, help to lead an company effectively and fairly. In their study, Xu et al. (2023) categorize corporate leaders into three groups based on years of experience. The first group consists of managers with 10 to 15 years of experience, the second group with 15 to 20 years and the third group with more than 20 years of experience. The authors wanted to investigate whether teams led by a combination of leaders from different groups perform better than teams led by leaders from the same group. They focus on shared leadership and emphasize that current market conditions require teams with different skill sets that complement each other. Their study has shown that teams made up of leaders from different experience groups perform significantly better than teams led by leaders from the same group. Teams

composed of different experience groups maximize long-term performance compared to homogeneous teams. However, leadership is not immune to outdated ideas and concepts which continue to be widely used even though they have proven ineffective and outdated. Such ideas are referred to as "zombie ideas" in leadership, as described by Haslam et al. (2024) in their research on outdated concepts that still linger among us. These ideas include the belief that employees are incapable of leading themselves and that they need a strict hierarchical structure with strong leaders at the top in order to function. Another idea is that leaders earn their place in the hierarchy because of innate leadership qualities that only a few individuals possess. A third idea is that any group success should be attributed solely to the leader and their actions that led to the positive outcome. But how can we combat these ideas? The authors emphasize that leadership must be based on relationships and connections between leaders and employees. The best evidence of a good leader is what their employees do and how they behave, because without followership there is no leadership. Furthermore, leadership is more about creating an atmosphere where employees are inspired to act rather than being forced to do something. And finally, leadership is a group process and is therefore based on collective activities.

As already mentioned, job satisfaction is a factor that is influenced by numerous variables, daily events and emotions and is subject to change. However, it arises and develops from the environment, as a result of these very events and the way in which the employee copes with everyday life. This gave rise to the idea of investigating the relationship between company management and employee satisfaction. At the beginning of their study, Kaur and Vij (2020) emphasize the role of management and the influence it can exert on employees through verbal and non-verbal communication in order to achieve certain goals. The authors also note that from the HR departments' perspective, employee satisfaction is extremely important for their performance and they confirm the theory of intrinsic and extrinsic employee motivation. The authors divide leadership into transformational and transactional leadership. Transformational leadership, as defined by Carrington et al. (2024), is an approach to leadership that promotes equality and inclusion and focuses on the development of skills, values and beliefs that leaders pass on to employees. Klein (2023) defines transactional leadership as leadership that is based on extrinsic motivation and assumes that an exchange of rewards will follow a job well done. In this type of leadership, a clearly defined set of rules is crucial. However, researchers in this field point out that such leadership can jeopardize the creativity of employees. Kaur and Vij (2020) examined several studies investigating the relationship between leadership and job satisfaction and contributed to the literature with their review. Their first research hypothesis states that the way an company is managed has a significant impact on employee satisfaction. Their study found a significant correlation between transformational leadership and employee satisfaction. The conclusion was that leadership which supports, motivates and responds to employees individually significantly increases employee satisfaction. In their study, Rosnizah et al. (2022) point out that leadership not only influences job satisfaction, but also general well-being, employee turnover, organizational productivity and employee attitudes. In this study, the authors examined the impact of leadership styles on job satisfaction, looking at transformational, transactional and laissez-faire leadership. Their study showed a significant correlation between laissez-faire and transformational leadership models and employee satisfaction. They concluded that management should not rely on a single leadership style, but should incorporate aspects of all leadership styles in order to achieve optimal employee satisfaction. Ramirez-Lozano et al. (2023) examined the influence of leadership on employee satisfaction and engagement in small and medium-sized enterprises. The authors emphasize that employee engagement and leadership are key to organizational success. Their study confirmed the

relationship between leadership, job satisfaction and employee engagement, contributing to the existing literature. Aljumah (2023) examined the relationship between employee satisfaction and leadership. The author emphasizes the importance of employee satisfaction as one of the top goals of management. He also emphasizes the importance of leadership in shaping employee satisfaction, focusing on transactional leadership. The authors argue that factors such as fair pay, bonuses and salary supplements in combination with transformational tools can strongly influence employee satisfaction and attitudes. They examined recognition, fair pay, performance rewards and employee support as factors that are influenced by leadership, affect employee satisfaction and increase both extrinsic and intrinsic motivation. In addition, the research showed that transactional leadership can influence overall employee motivation, including satisfaction, indicating the importance of organizations considering both leadership styles. Furthermore, Lutz et al. (2023) examine the relationship between leadership and employee health. In recent years, it has been increasingly recognized that leadership is a stress factor that affects employee health. The authors describe how transformational leadership can have a significant impact on employee health and that management is responsible for creating conditions that are not detrimental to employee well-being. This type of leadership is referred to as health-oriented leadership, which focuses on the health and well-being of employees. The study, which was conducted in Germany using questionnaires, showed a significant influence of health-oriented leadership on employee satisfaction. As can be seen from the literature reviewed, leadership and employee satisfaction are closely linked factors in employees' day-to-day work. The reviewed studies show that leadership is one of the key factors for employee satisfaction.

Methodology and research results

For the purpose of this study, a quantitative primary survey was conducted among employees of various organizations to examine their perceptions of leadership and job satisfaction. The sample of respondents was formed using simple random sampling among the employees of organizations in the Eastern Croatia region to ensure representativeness and diversity. The data was collected via an anonymous online survey. The standardized questionnaire used in the study consisted of three groups of questions: demographic variables (gender, age, work experience, etc.), perception of leadership in the organization and various dimensions of employee satisfaction. To ensure the relevance and reliability of the measurement instruments, the questionnaire was developed based on validated instruments from scientific studies by Tsai (2011) titled "Relationship between Organizational Culture, Leadership Behavior, and Job Satisfaction" and Paais & Pattiruhu (2020) titled "Effect of Motivation, Leadership, and Organizational Culture on Satisfaction and Employee Performance" This approach ensured that the measurement scales were scientifically sound and accurately reflected the concepts under study.

The collected data was processed using machine learning, in particular by using the Random Forest Algorithm to create a predictive model. The accuracy of the model was assessed using standard evaluation metrics such as accuracy, precision, recall and F1 score, as well as a confusion matrix analysis, which allows a detailed assessment of the model's performance. A feature importance analysis was also conducted to identify the most important factors influencing the model's predictions. SHAP (SHapley Additive exPlanations) analysis was also applied to better understand the individual contribution of each feature in the model's decision-making process and to gain insights into the specific impact of different variables on the classification of different categories. Data preparation is a crucial step in the machine learning

process as it ensures high-quality and well-structured input for analysis and modeling. Respondents answered the questionnaire using a 5-point Likert scale, which allowed quantification of their attitudes and perceptions. Each individual question was treated as a separate characteristic within the data set. To classify employee satisfaction, a dependent variable representing overall employee satisfaction was added to the dataset. This created a dataset suitable for supervised machine learning and enabled the application of classification and prediction algorithms.

The Random Forest algorithm was chosen to create the prediction model as it provides an integrated assessment of feature importance, is resistant to overfitting and can handle complex data. The dataset was split 70:30 — 70% of the data was used to train the machine learning model, while the remaining 30% was used to test the model and evaluate its performance. This split enables the model to learn patterns from the bulk of the data while testing its generalization ability on unseen data.

Table 1 Classification Results

Metric	Value	Explanation
Accuracy	0.548	The proportion of correctly predicted cases (both positives and negatives) out of all predictions. ~54.8% were correct.
Recall (Sensitivity)	0.75	The proportion of actual positive cases that were correctly identified. The model detected 75% of all real positives.
Precision	0.625	Proportion of predicted positives that were actually correct ($TP / (TP + FP) = 15 / (15 + 9)$).
F1 Score	0.682	Harmonic mean of precision and recall. Useful for imbalanced classes.
PR AUC	0.604	Area under the Precision-Recall curve. Reflects performance across thresholds for imbalanced datasets.
True Positives (TP)	15	Cases where the model correctly predicted the positive class.
False Positives (FP)	9	Cases where the model incorrectly predicted positive for a negative instance.
True Negatives (TN)	2	Cases where the model correctly predicted the negative class.
False Negatives (FN)	5	Cases where the model failed to identify a positive instance (predicted negative instead).

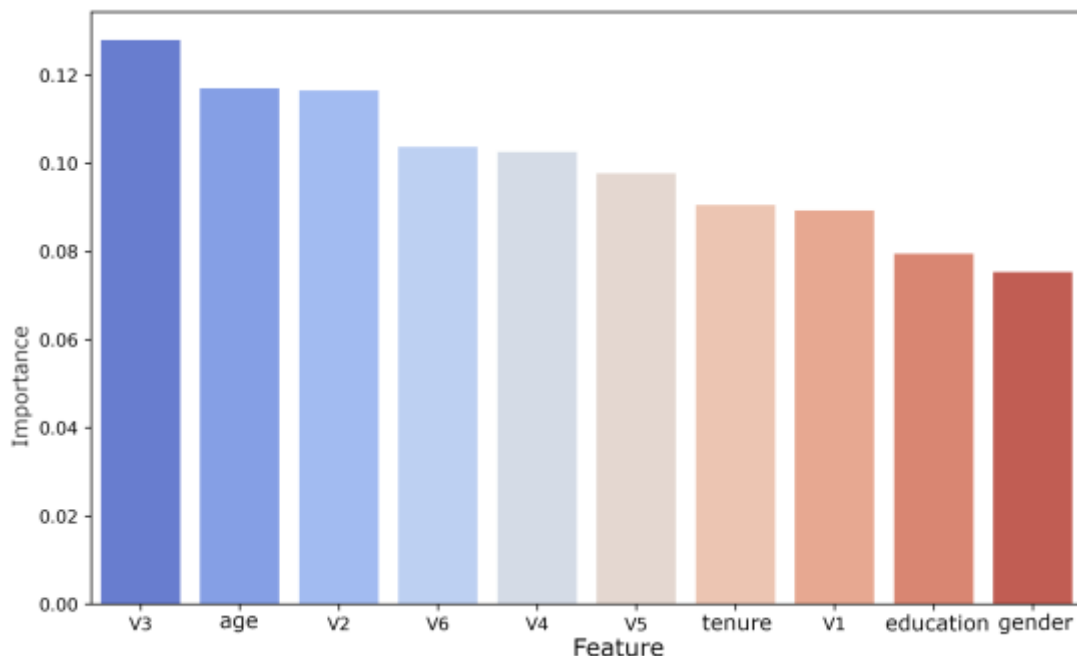
Sources – Author's own work

Table 1 shows the performance results of the Random Forest algorithm, which indicate a moderate predictive ability with certain limitations. The model achieved a recall value of 0.75, which means that it successfully identified 75% of the actual positive cases. This is a relatively high value and indicates that the model is effective in detecting relevant cases. The F1 score, which balances precision and recall, is 0.68, reflecting a reasonable trade-off between identifying positive cases and minimizing false positives. However, the PR AUC is 0.60, indicating a limited ability of the model to discriminate between positive and negative classes at different thresholds. The confusion matrix provides a clearer picture: the model correctly predicted 15 true positive and 2 true negative cases, but also made 9 false positive and 5 false negative errors. This imbalance—especially the high number of false positive cases—has a negative impact on the overall performance. The accuracy of the model is relatively low at 54.8%. This means that the model only classified just over half of the cases correctly. Given the

distribution of predictions shown in the confusion matrix, the model favors the positive class, which explains the higher hit rate but lower precision and accuracy. These results suggest that while the model is reasonably effective in identifying positive cases, further tuning of the model or additional data collection is needed to improve its reliability and generalization ability, especially in predicting the negative class. Feature importance analysis is one of the techniques used to explain the model, which helps to understand the influence of individual variables on the predictions. There are global and local approaches to analyzing feature importance: the global approach provides a general assessment of feature importance for the entire model, while the local approach provides a more detailed insight into the influence of features on individual predictions (Saarela & Jauhiainen, 2021).

By analyzing the built-in features of the Random Forest algorithm, the features with the greatest influence on the prediction of employee satisfaction could be identified, providing a better understanding of the key factors influencing the classification outcome.

Figure 1 Feature importances



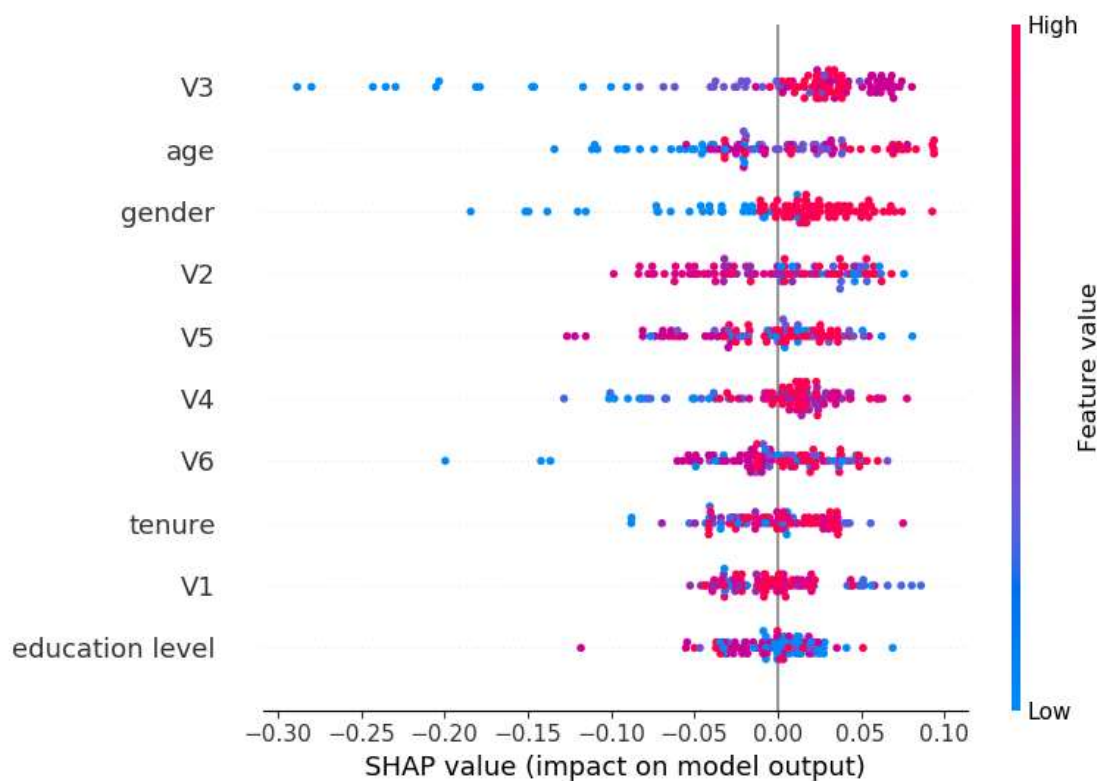
Sources – Author's own work

Figure 1 of the feature importance shows the relative influence of the different predictors on the model result. The most influential variable is V3 ("Our leader is a fair person"), which indicates that the perception of the supervisor's fairness makes the greatest contribution to the prediction of the dependent variable. This is followed by the variable "age", which also has a high influence, indicating that the age of the employee plays an important role in the model. The variables V2 ("My leader is always inviting employee discussions, especially matters relating to the level of employee welfare") and V6 ("Our leaders always think about the company and the interests of employees") follow with a significant contribution to the model. Variables V4 ("Our leader understands employees professionally; he can distinguish personal and professional matters"), V5 ("Our leaders give us confidence in doing work processes creatively as long as they do not violate company regulations") and "Level of education" have a moderate influence

On the other hand, V1 ("I feel that the direction of the place where I work has the responsibility and is reliable"), education, gender and a generic variable are at the bottom of the list, indicating their minimal contribution.

SHAP (SHapley Additive exPlanations) uses a concept from game theory to calculate the importance of characteristics. SHAP not only indicates the importance of the features, but also allows an understanding of the direction and extent of the influence of each variable on the prediction (Van den Broeck et al., 2022). Red dots represent high feature values, while blue dots represent low values.

Figure 2 SHAP analyses



Sources – Author's own work

The SHAP diagram shows that the most influential characteristics are V3 ("Our leader is a fair person"), age and gender. High values of V3 and higher age increase the performance of the model, while lower values decrease the prediction. Gender also shows a pronounced and variable effect, indicating the need to assess the fairness of the model. Characteristics such as V2, V4, V5, V6 and work experience show a moderate influence, while V1 and education have a minimal effect, which is reflected in their SHAP values close to zero.

The two visualizations provide complementary insights into the importance of the features within the machine learning model. The first figure is a bar chart showing the global importance of the features. Here, the most important features are V3, age and V2, while gender and education have a minor influence. This figure shows the extent of the influence, but not the direction (positive/negative). The second figure is the SHAP diagram, which additionally shows the direction and individual influence of each characteristic. Despite its lower overall ranking, gender shows a pronounced individual impact in the SHAP diagram, which means that it may be

important in certain cases. In summary, both charts confirm the importance of key variables such as V3 ("Our leader is a fair person") and age, but SHAP allows a deeper interpretation of the model's behavior. The combination of both methods provides a comprehensive and in-depth insight into the functioning of the model.

Conclusion

The results obtained confirm that understanding and improving leadership practices is the basis for building a more satisfied and motivated work environment. It is particularly important to identify the leadership dimensions that employees perceive as crucial to their satisfaction, such as fairness, open communication and the opportunity to participate in decision-making processes. The research results have shown that the Random Forest algorithm, although robust and interpretable, has moderate predictive ability in modeling employee satisfaction. The most important factors influencing the predictions are the perception of fairness of leadership, the age of employees and a participative leadership style. However, the limitations of the model, including the imbalance of the data and the high number of false positive predictions, indicate the need for further optimization. For future research, it is recommended to extend the data set, especially by including additional variables related to the work environment and psychological aspects of employees. Furthermore, the application of more advanced algorithms and data balancing techniques could improve the model's ability to accurately distinguish between positive and negative cases. Given the evidence of possible gender bias within the model, a thorough analysis of the fairness aspects is required, together with the implementation of methods that ensure equal treatment of all groups. The practical implications of this research relate to the potential use of predictive models as tools for identifying key factors in employee satisfaction. With appropriately interpretable models, organizations can identify areas for improvement in leadership and internal policies. However, for the reliable application of these models in practice, it is essential to ensure high quality, balanced data and to continuously monitor the performance of the model over time.

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