

Support Vector Machine Classification of Employees with High Innovative Work Behavior Using Psychological and Organizational Indicators

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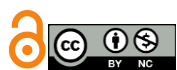
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ABSTRACT

Objective: This study aimed to classify Tunisian employees with high innovative work behavior using a Support Vector Machine model based on psychological and organizational indicators and to determine the relative contribution of these predictors to classification performance.

Methods and Materials: This quantitative cross-sectional predictive study was conducted among 418 employees working in public and private organizations in Tunis, Sfax, Sousse, and Monastir, Tunisia. Participants completed standardized measures of innovative work behavior, psychological capital, work engagement, intrinsic work motivation, creative self-efficacy, perceived organizational support, perceived supervisor support, organizational climate for innovation, job autonomy, and knowledge sharing. Employees scoring at or above the 75th percentile of innovative work behavior were classified as having high innovative work behavior. The dataset was divided into stratified training and independent test sets using an 80/20 ratio. A radial basis function Support Vector Machine was optimized through stratified five-fold cross-validation and grid search for C and gamma parameters. Classification performance was evaluated using accuracy, sensitivity, specificity, precision, F1 score, balanced accuracy, and ROC-AUC. Permutation-based feature importance was used to estimate the relative predictive contribution of each indicator.

Findings: The optimized SVM achieved cross-validated accuracy of .871, balanced accuracy of .858, and ROC-AUC of .918. In the independent test set, the model achieved accuracy of .857, sensitivity of .810, specificity of .873, precision of .680, F1 score of .739, balanced accuracy of .841, and ROC-AUC of .910. Creative self-efficacy showed the greatest permutation importance (.082), followed by organizational climate for innovation (.069), psychological capital (.058), work engagement (.046), knowledge sharing (.040), job autonomy (.034), intrinsic work motivation (.029), perceived organizational support (.024), and perceived supervisor support (.017).

Conclusion: Psychological and organizational indicators can classify employees with high innovative work behavior with substantial out-of-sample accuracy, with creative self-efficacy and organizational climate for innovation emerging as the strongest discriminative predictors.

Keywords: Innovative work behavior; Support Vector Machine; machine learning; creative self-efficacy; organizational climate; psychological capital; work engagement; Tunisia.

1 Introduction

Innovation has become a central requirement for organizational survival, adaptability, and sustainable performance in increasingly dynamic, knowledge-intensive, and technology-driven work environments. Organizations are no longer able to depend solely on formal research and development units or senior managers to generate innovative solutions; rather, innovation is increasingly shaped by employees who recognize problems, generate new ideas, promote those ideas, and contribute to their implementation in everyday work settings. Within this context, innovative work behavior has emerged as an important construct in organizational and human resource research because it captures the discretionary behaviors through which employees contribute directly to organizational renewal and improvement. Innovative work behavior generally extends beyond creativity alone, as it includes not only generating novel and useful ideas but also communicating, championing, adapting, and implementing those ideas within the organizational environment. Contemporary studies have therefore approached innovative work behavior as a multidimensional behavioral phenomenon that can influence organizational performance, adaptability, service quality, business model development, and long-term competitiveness (Aziz, 2025; Hock-Doepgen et al., 2025; Waheed & Khan, 2025).

The growing importance of innovative work behavior is particularly evident in environments characterized by rapid technological change, digital transformation, competitive uncertainty, and pressure for sustainability. Employees are increasingly expected to respond to new technologies, changing customer expectations, and evolving organizational structures by engaging in adaptive and innovative behavior. Recent research has linked innovative work behavior to employability, digital literacy, and contextual human resource management practices, emphasizing that employees' capacity to innovate is shaped by interactions between personal competencies and the broader work environment (Caroline et al., 2025). Likewise, the increasing use of artificial intelligence in organizational and professional settings has created new opportunities for employees to develop creative and innovative work practices, although the transformation of technological resources into innovative behavior often depends on human creativity and the capacity to integrate technology into meaningful work processes (Andayesh, 2025). In service settings, innovative work behavior has also been connected

to sustainability-oriented development, suggesting that employee innovation may contribute not only to organizational efficiency but also to broader environmental and social objectives (Yusriani et al., 2025). These developments have intensified interest in identifying the individual and organizational conditions that differentiate employees who demonstrate particularly high levels of innovative work behavior.

A major stream of research has focused on leadership as an important antecedent of employee innovation. Leadership can influence employees' willingness to question established routines, experiment with alternative solutions, and persist in the implementation of new ideas. Transformational leadership, for example, may create an inspiring and psychologically supportive environment by communicating a compelling vision, encouraging intellectual stimulation, and providing individualized consideration. Recent evidence suggests that transformational leadership can influence innovative work behavior through psychological empowerment and work engagement, demonstrating that leadership may facilitate innovation partly by strengthening employees' perceived autonomy, competence, and involvement in their work (Vu et al., 2025). Transformational leadership has also been identified as an important mechanism for moving employees from idea exploration toward actual implementation, highlighting the behavioral progression inherent in innovative work behavior (Phairat et al., 2026). In addition, research among younger employees has indicated that transformational and shared leadership may operate through organizational climate, reinforcing the view that leadership affects innovative behavior partly by shaping employees' perceptions of whether experimentation, participation, and new ideas are genuinely encouraged within the organization (Hamidah & Antonio, 2025).

Other leadership approaches have also received increasing attention. Ambidextrous leadership, which involves balancing exploratory and exploitative leadership behaviors, may be particularly relevant in organizational environments that require both creativity and disciplined implementation. Evidence from healthcare organizations has suggested that ambidextrous leadership can strengthen innovative work behavior by creating conditions in which employees are simultaneously encouraged to generate new ideas and align those ideas with practical organizational requirements (Attique et al., 2025). Empowering leadership represents another relevant approach because it delegates authority, supports participation, and encourages employees

to exercise independent judgment. In educational contexts, empowering leadership has been associated with teachers' innovative work behavior, with professional development serving as an important mediating mechanism (Ghanbari & Norouzi, 2025). Entrepreneurial leadership has similarly been linked to innovative behavior through psychological and learning-related mechanisms, particularly creative self-efficacy and organizational learning (Takeed et al., 2025). These findings collectively suggest that leadership influences innovation not merely through direct supervision but also through employees' psychological resources and their perceptions of organizational support for experimentation and learning.

Psychological factors constitute another major explanatory domain. Innovative behavior involves uncertainty, potential failure, social exposure, and the possibility that new ideas may be rejected. Employees therefore require psychological resources that enable them to persist despite ambiguity and interpersonal risk. Creative self-efficacy is particularly important because it reflects employees' confidence in their capacity to generate creative outcomes and solve problems in novel ways. Employees with stronger creative self-efficacy may be more willing to propose unconventional solutions, defend innovative ideas, and invest sustained effort in implementation. The mediating role of creative self-efficacy in the relationship between entrepreneurial leadership and innovative work behavior supports its position as a key psychological mechanism linking organizational conditions to innovation (Takeed et al., 2025). Psychological empowerment is also repeatedly identified as a relevant predictor because employees who perceive greater meaning, competence, self-determination, and impact in their work are more likely to behave proactively and innovatively. Structural equation modeling research has shown that psychological empowerment can transmit the effects of talent management practices to innovative work behavior, illustrating how organizational systems may influence innovation through employees' internal motivational states (Sanusi et al., 2025).

Work engagement represents another central psychological mechanism. Employees who are vigorous, dedicated, and absorbed in their work are more likely to invest cognitive and emotional resources in identifying problems and developing improved methods. High-performance work systems have been shown to promote innovative work behavior through increased work engagement, suggesting that organizational practices influence innovation partly by affecting the quality of

employees' involvement with their work (Husin et al., 2025). Similar results have been reported for transformational leadership, with work engagement functioning as a pathway through which supportive and inspirational leadership translates into greater innovative behavior (Vu et al., 2025). Research on teachers has further shown that work engagement can operate alongside creativity and proactive personality in explaining innovative work behavior, especially within digitally oriented leadership environments (Siregar et al., 2026). These findings indicate that innovation is unlikely to depend solely on employee ability; rather, employees must also possess sufficient motivation, energy, and psychological investment to transform potentially creative thoughts into sustained innovative action.

Beyond individual psychological characteristics, organizational resources and social conditions shape whether innovative ideas are encouraged, developed, or suppressed. Perceived organizational support is particularly important because innovation often requires employees to expend effort beyond prescribed job requirements while accepting the possibility of uncertainty and failure. When employees perceive that the organization values their contributions, supports experimentation, and provides resources for implementing new ideas, they may be more willing to engage in innovative behavior. Organizational support has consequently been linked to the capacity of employee innovative behavior to contribute to broader organizational outcomes such as business model innovation (Hock-Doepgen et al., 2025). Organizational commitment may also function as a social-psychological driver of innovation, as employees who are more strongly attached to their organizations may be more willing to invest discretionary effort in developing and implementing improvements (Xu & Phanniphong, 2025). These relationships suggest that innovative work behavior is embedded within an exchange relationship between employees and their organizations, in which perceived support, commitment, and reciprocal investment may influence the willingness to innovate.

Organizational climate is another important contextual factor. An innovation-supportive climate communicates that creativity, experimentation, learning, and constructive risk taking are acceptable and valued. Such a climate can reduce employees' uncertainty concerning whether new ideas will be welcomed and can strengthen the perceived legitimacy of innovative action. Evidence from creative industries indicates that organizational climate may mediate the effects

of transformational and shared leadership on innovative work behavior (Hamidah & Antonio, 2025). A collaborative atmosphere can similarly enhance innovative work behavior by facilitating interpersonal exchange, shared problem solving, and access to diverse knowledge resources (Liu & Sun, 2025). These findings are particularly important because innovation is rarely an entirely individual process. Even when an idea originates with one employee, its refinement and implementation usually depend on cooperation, feedback, access to resources, and support from coworkers and supervisors.

Knowledge sharing is therefore another organizational-social indicator closely associated with innovative work behavior. Employees who exchange information, experience, and expertise with colleagues gain access to more diverse perspectives and may be better positioned to recombine existing knowledge into new solutions. Knowledge sharing can also facilitate the transition from idea generation to implementation by enabling employees to obtain technical information, feedback, and social support. Recent research has emphasized the interconnected roles of interpersonal communication and knowledge sharing in shaping innovative work behavior, indicating that collaboration provides an important social foundation for creativity and innovation (Munawaroh et al., 2025). Similarly, research examining psychological empowerment and kinship employee engagement has shown that sharing-oriented relational environments can reinforce innovative work behavior by increasing employees' sense of psychological connection and participation (Marampa et al., 2025). Thus, innovation appears to arise partly from the interaction between employees' internal psychological resources and their ability to access and mobilize collective organizational knowledge.

Human resource management practices can further shape the organizational conditions under which innovation becomes more likely. Human resource systems influence employee development, skill flexibility, autonomy, participation, motivation, and perceptions of organizational investment. Studies have suggested that human resource management actions may enhance innovative work behavior through human resource flexibility, particularly when employees have the capacity to adapt their skills and behavior to changing organizational requirements (Masoudnia & Nasti Zayi, 2025). High-performance work systems can likewise influence innovation through work engagement by creating mutually reinforcing practices related to training, performance management, employee

participation, and support (Husin et al., 2025). In sustainability-oriented contexts, green human resource management has been linked to green innovative work behavior, indicating that human resource practices can direct employee innovative efforts toward specific strategic priorities (Khan et al., 2025). Employee participation has also been identified as an important mechanism connecting green human resource management with green innovative work behavior, emphasizing the importance of giving employees meaningful opportunities to contribute to organizational decision-making (Piwowar-Sulej & Iqbal, 2025).

The importance of professional development provides further support for the role of organizational investment in innovation. Employees are more likely to innovate when they continuously develop their professional knowledge, acquire new competencies, and encounter alternative ways of performing their work. Research involving teachers has highlighted professional development strategies as an important foundation for innovative work behavior, particularly where employees must respond to changing pedagogical, technological, and institutional expectations (Ramezani & Mirkazemi, 2025). Similarly, empowering leadership has been associated with innovative work behavior through professional development, indicating that leadership and employee development may operate as complementary mechanisms (Ghanbari & Norouzi, 2025). These findings imply that organizations seeking innovation must move beyond exhortations to "be creative" and instead establish systems that develop employees' capabilities, autonomy, confidence, and access to learning opportunities.

The diversity of determinants identified in recent research illustrates both the strength and limitation of the existing innovative work behavior literature. Considerable evidence demonstrates associations between innovative work behavior and leadership, psychological empowerment, work engagement, creative self-efficacy, organizational climate, knowledge sharing, human resource practices, employee participation, professional development, and organizational commitment (Bui et al., 2025; Liu & Sun, 2025; Masoudnia & Nasti Zayi, 2025; Sanusi et al., 2025). However, many studies continue to rely primarily on explanatory statistical models that estimate the independent or mediated effects of a relatively limited set of predictors. Such approaches are valuable for testing theoretical relationships, but they do not directly address an increasingly important applied question: whether employees who exhibit exceptionally high innovative work behavior can be accurately classified from

a combination of psychological and organizational indicators. This distinction is important because explanation and prediction are related but not identical objectives. A variable may demonstrate a statistically significant average association with innovative work behavior without necessarily providing strong discriminative value when combined with multiple correlated predictors.

The growing complexity of innovative work behavior also creates a strong rationale for applying machine-learning methods. Employee innovation may result from nonlinear combinations of personal and contextual factors rather than from simple additive effects. For example, high creative self-efficacy may generate stronger innovative behavior when employees simultaneously experience autonomy and organizational support, while strong organizational support may have limited effects when employees lack engagement or intrinsic motivation. Conventional regression-based techniques can test selected interaction or nonlinear effects, but the number and form of these relationships must generally be specified in advance. Machine-learning classifiers can complement traditional explanatory analyses by identifying complex decision boundaries among multiple predictors and evaluating how accurately those predictors distinguish predefined employee groups. Support Vector Machine classification is particularly relevant for this purpose because it seeks an optimal separating boundary between classes and can employ nonlinear kernels when the data are not linearly separable. In the context of innovative work behavior, such an approach provides a means of shifting from the general question of which factors correlate with innovation toward the more practically oriented question of whether a multivariate psychological-organizational profile can identify highly innovative employees.

This predictive perspective is also relevant to contemporary human resource management. Organizations increasingly use evidence-based and data-informed approaches to employee development, talent management, job design, and innovation management. A reliable classification model could help researchers understand the configurations of attributes that characterize highly innovative employees, while also informing organizational interventions directed toward innovation-supportive environments. Talent management research already indicates that psychological empowerment can serve as an important mechanism linking organizational talent practices to innovation (Sanusi et al., 2025), while human resource flexibility may transmit the influence of broader HRM

actions (Masoudnia & Nasti Zayi, 2025). Studies of transformational leadership, organizational citizenship behavior, and employee performance likewise demonstrate that innovative work behavior operates within broader networks of employee attitudes and organizational outcomes (Bui et al., 2025). Accordingly, a predictive model incorporating multiple psychological and organizational indicators may offer greater practical value than examining each determinant in isolation.

The need for such integrative analysis is reinforced by the fact that innovative work behavior has been studied across markedly different occupational and cultural settings, including hospitals, banks, educational organizations, creative industries, service-sector workplaces, hospitality organizations, and universities (Attique et al., 2025; Aziz, 2025; Bui et al., 2025; Khan et al., 2025; Xu & Phanniphong, 2025). This diversity demonstrates the broad relevance of innovative behavior but also highlights the importance of contextual examination. National and organizational environments can differ considerably in leadership structures, workplace autonomy, resource availability, employee-management relationships, and norms surrounding initiative and risk. Consequently, predictive patterns established in one national setting cannot automatically be assumed to generalize to another. Much of the recent empirical literature represented in current scholarship has focused on Asian, Middle Eastern, or selected European organizational settings, while comparatively less attention has been directed toward North African employee populations. Examining employees in Tunisia therefore provides an opportunity to extend the study of innovative work behavior into a context characterized by ongoing economic modernization, digitalization, public- and private-sector development, and increasing organizational demand for adaptability and innovation.

Recent scholarship also indicates that no single predictor is likely to provide a sufficient account of high innovative work behavior. Leadership can encourage innovation, but its effects may depend on employee empowerment and engagement (Phairat et al., 2026; Vu et al., 2025). Human resource practices can provide resources and opportunities, but employees must be psychologically prepared to use them innovatively (Husin et al., 2025; Piwowar-Sulej & Iqbal, 2025). Collaboration and knowledge sharing can expose employees to diverse information, but translating that information into innovation may require creativity and confidence (Marampa et al., 2025; Munawaroh et al., 2025). Digital tools and artificial intelligence may increase access

to new capabilities, but creativity remains important for converting technological affordances into innovative outputs (Andayesh, 2025). Likewise, digital leadership can foster innovative work behavior through creativity, proactive tendencies, and work engagement (Siregar et al., 2026). These interconnected findings support an integrated perspective in which innovative work behavior is conceptualized as the outcome of a psychological-organizational system rather than a single isolated antecedent.

Accordingly, integrating psychological capital, work engagement, intrinsic work motivation, creative self-efficacy, perceived organizational support, perceived supervisor support, organizational climate for innovation, job autonomy, and knowledge sharing within a single classification model provides both theoretical and methodological value. These variables collectively represent employees' psychological readiness to innovate, their energetic and motivational investment in work, their confidence in creative performance, and their perceptions of whether the organizational environment supplies adequate autonomy, support, collaboration, and legitimacy for innovation. This integrated perspective is consistent with contemporary evidence emphasizing the joint influence of employee-level and context-level resources on innovative behavior (Caroline et al., 2025; Waheed & Khan, 2025). It also extends recent research focused on domain-specific forms of innovation, including green innovative work behavior, professional innovation, and technology-enabled innovation, by examining the broader classification of employees who exhibit particularly high levels of innovative work behavior (Khan et al., 2025; Ramezani & Mirkazemi, 2025; Yusriani et al., 2025).

A classification-oriented approach may also provide a clearer understanding of relative predictor importance. Statistical significance does not necessarily imply substantial predictive contribution, particularly when multiple predictors share overlapping variance. For instance, perceived organizational support, supervisor support, organizational climate, and leadership-related resources may be positively related to each other while contributing differently to the actual discrimination of highly innovative employees. Similarly, psychological variables such as work engagement, psychological empowerment, creative self-efficacy, and proactive tendencies may represent overlapping but distinguishable motivational resources (Sanusi et al., 2025; Siregar et al., 2026). By using an SVM classifier together with model-evaluation indices and

feature-importance analysis, it becomes possible to examine not only whether employees can be classified accurately but also which characteristics contribute most strongly to that classification. Such evidence can complement conventional association-based research and provide a more operational understanding of the profiles associated with exceptional innovative behavior.

From an organizational perspective, distinguishing employees with high innovative work behavior can also have practical implications for workforce development, although predictive models should be used as decision-support tools rather than deterministic systems for employee evaluation. Organizations may use knowledge of predictive indicators to design interventions that strengthen creative self-efficacy, psychological capital, engagement, autonomy, knowledge exchange, and innovation-supportive climates across the workforce. This emphasis is consistent with research showing that employee innovation can be developed through supportive leadership, participation, professional development, and well-designed human resource systems rather than regarded solely as a fixed individual characteristic (Ghanbari & Norouzi, 2025; Piwowar-Sulej & Iqbal, 2025). Furthermore, because innovative work behavior contributes to broader outcomes such as employee performance and organizational business model innovation, strengthening the conditions associated with employee innovation may produce benefits beyond individual creativity (Bui et al., 2025; Hock-Doepgen et al., 2025). An integrated predictive model can therefore contribute both to organizational behavior theory and to evidence-based human resource management by clarifying how individual and contextual resources jointly differentiate highly innovative employees.

Despite the rapid expansion of research on innovative work behavior, an important gap remains in the application of nonlinear supervised learning methods to classify employees with particularly high innovative behavior using a comprehensive combination of psychological and organizational features, especially in the Tunisian context. Existing studies have established important theoretical relationships involving leadership, engagement, empowerment, organizational commitment, knowledge sharing, organizational climate, and human resource systems, but they have largely emphasized explanation rather than out-of-sample classification (Hamidah & Antonio, 2025; Liu & Sun, 2025; Xu & Phanniphong, 2025). A Support Vector Machine approach can address this gap by testing whether information distributed across several

employee and organizational characteristics can be combined into a decision boundary capable of distinguishing high-innovation employees from others. Evaluating the model on an independent test sample further allows predictive performance to be assessed beyond the data used to construct the classifier, while feature-importance analysis provides additional evidence regarding the relative contribution of individual predictors.

Therefore, the aim of the present study was to classify Tunisian employees with high innovative work behavior using a Support Vector Machine model based on psychological and organizational indicators and to determine the relative contribution of these indicators to classification performance.

2 Methods and Materials

This study employed a quantitative, cross-sectional, predictive research design to classify employees with high innovative work behavior based on a set of psychological and organizational indicators using a Support Vector Machine (SVM) algorithm. The study population consisted of employees working in public and private organizations in Tunisia. Participants were recruited from organizations operating in the service, information technology, banking and financial services, telecommunications, manufacturing, education, and administrative sectors in Tunis, Sfax, Sousse, and Monastir. A multistage sampling procedure was used to obtain a heterogeneous sample representing employees from different occupational and organizational environments. At the first stage, organizations from the major public and private employment sectors were identified, and permission for data collection was obtained from their administrative or human resource departments. At the second stage, employees within participating organizations were approached through convenience sampling while attempting to maintain diversity in terms of sex, age, occupational position, organizational tenure, and type of organization. The inclusion criteria were being at least 18 years of age, being employed on a full-time basis, having worked in the current organization for at least six months, and providing informed consent to participate. Employees who were working on a temporary internship basis, had less than six months of organizational experience, or returned questionnaires with substantial missing information were excluded from the study.

A total of 468 Tunisian employees were initially invited to participate in the study. Of these, 439 returned the

questionnaires. After screening the data for completeness and response quality, 21 questionnaires were excluded because of excessive missing data, patterned responses, or failure to meet the inclusion criteria. Therefore, the final analytical sample consisted of exactly 418 employees. The sample size was considered adequate for both conventional statistical analyses and supervised machine-learning classification because it provided a sufficient number of observations relative to the number of predictor variables included in the classification model. Participants represented a broad range of occupational levels, including administrative employees, professional and technical personnel, supervisors, middle-level managers, and other organizational staff. Data collection was conducted anonymously, and participation was entirely voluntary. Before completing the questionnaires, participants received information explaining the objectives of the study, confidentiality of the collected information, voluntary participation, and their right to withdraw from the study without any consequences. No personally identifying information was collected. The research procedures were conducted in accordance with the ethical principles governing research involving human participants, including confidentiality, informed consent, voluntary participation, and secure handling of research data.

Data were collected using a structured questionnaire consisting of demographic information and standardized measures of innovative work behavior and selected psychological and organizational indicators theoretically associated with employees' innovation. The demographic section included age, sex, educational level, organizational sector, occupational position, and organizational tenure. Innovative work behavior was assessed using the nine-item Innovative Work Behavior Scale developed by Janssen. The scale evaluates employees' engagement in the major stages of workplace innovation, including idea generation, idea promotion, and idea realization. Respondents indicated the extent to which they engaged in each innovative behavior using a Likert-type response format ranging from low to high frequency. A total innovative work behavior score was calculated by averaging the responses across the items, with higher scores indicating greater engagement in innovative behaviors at work. For the machine-learning analysis, innovative work behavior served as the outcome variable. Employees were classified into high and non-high innovative work behavior groups on the basis of the distribution of the total innovative work behavior score. Participants scoring at or above the 75th percentile were

categorized as employees with high innovative work behavior, whereas participants scoring below the 75th percentile were categorized as the comparison class. This operationalization was selected to identify employees demonstrating a distinctly elevated level of innovative behavior rather than merely distinguishing individuals above and below the sample mean.

Psychological indicators included psychological capital, work engagement, intrinsic work motivation, and creative self-efficacy. Psychological capital was measured using the Psychological Capital Questionnaire, which assesses the positive psychological resources of self-efficacy, hope, resilience, and optimism. The items were rated on a Likert-type scale, and higher total scores reflected stronger positive psychological capital. Work engagement was assessed using the Utrecht Work Engagement Scale, covering vigor, dedication, and absorption. Higher scores indicated a greater level of energetic and persistent involvement in work activities. Intrinsic work motivation was evaluated through items assessing the extent to which employees performed their work because they experienced it as interesting, personally meaningful, challenging, and inherently satisfying rather than primarily because of external rewards. Creative self-efficacy was assessed as employees' confidence in their ability to produce creative ideas, develop novel solutions, and perform tasks requiring creativity. Higher scores on all psychological measures indicated stronger levels of the corresponding psychological resource. These indicators were selected because innovative behavior involves not only generating new ideas but also persisting in their development, communicating them to others, and attempting to implement them within the organizational environment.

The organizational indicators included perceived organizational support, perceived supervisor support, organizational climate for innovation, job autonomy, and knowledge sharing. Perceived organizational support was assessed through items derived from the Survey of Perceived Organizational Support and reflected employees' perceptions that their organization valued their contributions and cared about their well-being. Perceived supervisor support assessed the extent to which immediate supervisors provided encouragement, recognition, assistance, and constructive support for employees' work-related initiatives. Organizational climate for innovation measured employees' perceptions of whether the work environment encouraged experimentation, openness to new ideas, calculated risk taking, and implementation of novel approaches. Job

autonomy was measured through items evaluating employees' perceived discretion over work methods, scheduling, and decision-making. Knowledge sharing was assessed through items reflecting the frequency and willingness with which employees exchanged work-related information, expertise, experiences, and useful ideas with colleagues. Responses to the psychological and organizational measures were recorded using Likert-type rating scales, and composite scores were computed according to their respective scoring procedures. Before the primary analyses, the internal consistency of each multi-item scale was examined using Cronbach's alpha, with coefficients of .70 or higher regarded as evidence of acceptable internal consistency. Where necessary for the Tunisian context, the questionnaire was administered in French or Arabic according to the participant's preferred language. Translation equivalence was ensured through forward translation, independent back-translation, comparison of the translated and original versions, and review by bilingual experts familiar with organizational psychology and human resource management terminology.

Data analysis was conducted in two complementary stages consisting of preliminary statistical analysis and machine-learning classification. Initially, the dataset was examined for missing values, invalid responses, univariate outliers, and distributional abnormalities. Descriptive statistics, including means, standard deviations, frequencies, percentages, minimums, and maximums, were calculated to characterize the participants and the study variables. Internal consistency reliability was assessed for all multi-item measures using Cronbach's alpha. Correlation analysis was subsequently performed to examine the bivariate relationships among innovative work behavior and the psychological and organizational indicators. Prior to machine-learning modeling, continuous predictor variables were standardized using z-score transformation so that differences in the original measurement scales would not disproportionately affect the SVM optimization procedure. The outcome variable was coded as a binary classification target, with employees meeting the predefined criterion for high innovative work behavior coded as 1 and all other employees coded as 0. The class distribution was examined before model development because the use of the upper quartile as the classification threshold resulted in fewer employees in the high innovative work behavior category than in the comparison category. To minimize the influence of class imbalance, class-weighted SVM estimation was

applied so that errors in the minority class received greater weight during model training.

The dataset was randomly divided into a training set containing 80% of the participants and an independent test set containing the remaining 20%. Stratified sampling was used during this partitioning process to preserve approximately the same proportion of high innovative work behavior cases in both subsets. All preprocessing procedures requiring parameter estimation, including standardization, were fitted to the training data and subsequently applied to the test data in order to prevent information leakage. An SVM classifier was then developed using the psychological and organizational indicators as predictor features. Because the relationship between employee characteristics and innovative work behavior was expected to involve potentially nonlinear interactions, a radial basis function kernel was selected as the principal SVM kernel. The two main hyperparameters of the radial basis function SVM, the penalty parameter C and the kernel coefficient γ , were optimized using a grid-search procedure combined with stratified five-fold cross-validation within the training dataset. In each cross-validation iteration, four folds were used to train the classifier and the remaining fold was used for validation, with the procedure repeated until each fold had served as the validation subset. The hyperparameter combination producing the strongest cross-validated classification performance was retained and used to fit the final SVM model on the complete training dataset.

The predictive performance of the final classifier was evaluated using the previously unseen test dataset. Because overall accuracy alone may provide a misleading estimate when class frequencies are unequal, model evaluation was based on several complementary indices, including accuracy, sensitivity, specificity, precision, F1 score, balanced accuracy, and the area under the receiver operating characteristic curve. Sensitivity represented the proportion of employees with high innovative work behavior who were correctly identified by the model, whereas specificity represented the proportion of employees without high innovative work behavior who were correctly classified. Precision indicated the proportion of cases predicted as highly innovative that actually belonged to the high innovative work behavior category, and the F1 score represented the harmonic mean of precision and sensitivity. The receiver operating characteristic curve and its area under the curve were used to evaluate the model's overall discriminative capacity across alternative classification thresholds. A confusion matrix was also examined to

determine the numbers of true positive, true negative, false positive, and false negative classifications.

To determine the relative contribution of the psychological and organizational indicators to classification performance, permutation-based feature importance was calculated using the final trained model. Each predictor was randomly permuted while the remaining predictors were kept unchanged, and the resulting reduction in predictive performance was used as an indicator of its importance to the classification model. Larger decreases in performance indicated that the corresponding predictor contributed more strongly to distinguishing employees with high innovative work behavior. This model-interpretation procedure was used because nonlinear SVM models do not provide directly interpretable regression coefficients comparable to those obtained from conventional linear models. All statistical tests were two-tailed, and a significance level of $p < .05$ was used for inferential statistical analyses. The machine-learning procedures were implemented using a reproducible analytical workflow that maintained strict separation between the training and testing datasets throughout preprocessing, hyperparameter optimization, model estimation, and final performance evaluation.

3 Findings and Results

The final sample consisted of 418 employees from public and private organizations in Tunisia. Of the participants, 224 (53.59%) were men and 194 (46.41%) were women. With respect to age, 86 participants (20.57%) were between 18 and 29 years, 156 (37.32%) were between 30 and 39 years, 111 (26.56%) were between 40 and 49 years, and 65 (15.55%) were aged 50 years or older. Regarding educational attainment, 47 employees (11.24%) had completed secondary or equivalent education, 201 (48.09%) held a bachelor's degree, 133 (31.82%) held a master's degree, and 37 (8.85%) held a doctoral or equivalent advanced degree. A total of 253 participants (60.53%) were employed in private-sector organizations, whereas 165 (39.47%) worked in public-sector organizations. Geographically, 184 participants (44.02%) were employed in Tunis, 91 (21.77%) in Sfax, 82 (19.62%) in Sousse, and 61 (14.59%) in Monastir. In terms of occupational position, 104 participants (24.88%) held administrative positions, 152 (36.36%) were professional or technical employees, 72 (17.22%) were supervisors, 54 (12.92%) were middle-level managers, and 36 (8.61%) occupied other organizational positions. Organizational tenure was less than three years for

83 employees (19.86%), between three and seven years for 132 (31.58%), between eight and twelve years for 101 (24.16%), and more than twelve years for 102 (24.40%). Overall, the demographic distribution indicated substantial heterogeneity in age, education, organizational sector, occupational position, and tenure, thereby providing an appropriate employee sample for examining psychological and organizational predictors of innovative work behavior.

Application of the predefined upper-quartile criterion to the total innovative work behavior score identified 105 employees (25.12%) as demonstrating high innovative work behavior and 313 employees (74.88%) as belonging to the non-high innovative work behavior category. The 75th-percentile cutoff corresponded to a total mean item score of

approximately 4.00 on the innovative work behavior measure. Thus, employees classified in the high innovative work behavior group represented those who reported consistently frequent engagement in idea generation, idea promotion, and idea implementation rather than those who merely scored above the overall sample mean. Stratification was maintained during data partitioning. Consequently, the training dataset consisted of 334 employees, including 84 employees with high innovative work behavior and 250 employees in the non-high category, whereas the independent test dataset consisted of 84 employees, including 21 employees with high innovative work behavior and 63 employees in the non-high category.

Table 1

Descriptive Statistics, Internal Consistency, and Correlations of Study Variables with Innovative Work Behavior

Variable	M	SD	Cronbach's α	Correlation with Innovative Work Behavior (r)	p
Psychological capital	3.71	0.62	.89	.52	< .001
Work engagement	3.66	0.70	.91	.49	< .001
Intrinsic work motivation	3.74	0.67	.86	.45	< .001
Creative self-efficacy	3.69	0.65	.88	.58	< .001
Perceived organizational support	3.51	0.72	.90	.41	< .001
Perceived supervisor support	3.46	0.77	.88	.37	< .001
Organizational climate for innovation	3.43	0.69	.92	.55	< .001
Job autonomy	3.58	0.71	.85	.44	< .001
Knowledge sharing	3.73	0.64	.87	.47	< .001
Innovative work behavior	3.47	0.72	.93	—	—

As shown in Table 1, all study instruments demonstrated satisfactory to excellent internal consistency, with Cronbach's alpha coefficients ranging from .85 for job autonomy to .93 for innovative work behavior. Accordingly, none of the scales fell below the predefined acceptable reliability threshold of .70. The highest average score among the predictor variables was observed for intrinsic work motivation ($M = 3.74$, $SD = 0.67$), followed closely by knowledge sharing ($M = 3.73$, $SD = 0.64$) and psychological capital ($M = 3.71$, $SD = 0.62$). Perceived supervisor support had the lowest mean among the predictors ($M = 3.46$, $SD = 0.77$), although its average level remained above the midpoint of the response scale. The mean innovative work behavior score for the entire sample was 3.47 ($SD = 0.72$). All psychological and organizational indicators were positively and statistically significantly associated with innovative work behavior. Creative self-efficacy demonstrated the strongest zero-order association with innovative work behavior, $r = .58$, $p < .001$, indicating that employees with stronger confidence in their capacity to

develop creative solutions were substantially more likely to report innovative behavior. Organizational climate for innovation showed the second strongest relationship, $r = .55$, $p < .001$, followed by psychological capital, $r = .52$, $p < .001$, and work engagement, $r = .49$, $p < .001$. Knowledge sharing was also moderately associated with innovative work behavior, $r = .47$, $p < .001$, as were intrinsic work motivation, $r = .45$, $p < .001$, and job autonomy, $r = .44$, $p < .001$. Perceived organizational support showed a positive correlation of $r = .41$, $p < .001$, whereas perceived supervisor support, although producing the smallest correlation among the predictors, remained significantly associated with innovative work behavior, $r = .37$, $p < .001$. Taken together, these results indicated that high innovative work behavior was associated with both individual psychological resources and characteristics of the organizational environment, thereby supporting their simultaneous inclusion as predictor features in the subsequent SVM classification model.

Prior to fitting the SVM classifier, the predictor variables were standardized using parameters estimated exclusively

from the training dataset. Examination of the training data revealed no predictor with a level of missingness requiring removal from the model, and cases with substantial missing responses had already been excluded during the preliminary screening stage. Because the outcome distribution was intentionally asymmetric as a consequence of defining the high innovative work behavior group according to the upper quartile, class weighting was incorporated into the SVM optimization process. A radial basis function kernel was

used to permit nonlinear separation between the two employee classes. Hyperparameter optimization was performed through grid search within stratified five-fold cross-validation. The strongest cross-validated solution was obtained with a penalty parameter of $C = 10.00$ and a gamma value of 0.10 . These values were subsequently used to fit the final classifier to the entire training dataset before evaluation against the independent test sample.

Table 2

Cross-Validated and Independent Test Performance of the Support Vector Machine Classifier

Model Characteristic / Performance Index	Five-Fold Cross-Validation	Independent Test Set
Kernel	Radial basis function	Radial basis function
Optimal C	10.00	10.00
Optimal gamma	0.10	0.10
Accuracy	.871	.857
Sensitivity	.829	.810
Specificity	.887	.873
Precision	.714	.680
F1 score	.768	.739
Balanced accuracy	.858	.841
ROC-AUC	.918	.910
True positives	—	17
True negatives	—	55
False positives	—	8
False negatives	—	4

Table 2 presents the predictive performance of the optimized SVM model. During stratified five-fold cross-validation within the training dataset, the classifier achieved an average accuracy of .871 and a balanced accuracy of .858, indicating that performance was not attributable solely to successful prediction of the larger non-high innovative work behavior class. Cross-validated sensitivity was .829, demonstrating that approximately 82.9% of employees displaying high innovative work behavior were correctly detected during model development, whereas specificity was .887, showing that 88.7% of employees who did not meet the high innovative work behavior criterion were correctly classified. The cross-validated precision of .714 indicated that approximately 71.4% of cases classified by the algorithm as highly innovative actually belonged to the high innovative work behavior class. The corresponding F1 score was .768, reflecting a favorable balance between precision and sensitivity. Moreover, the cross-validated ROC-AUC of .918 indicated excellent discrimination between the two employee groups across potential classification thresholds. Importantly, performance remained comparatively stable when the model was evaluated on the completely

independent test dataset. The final test accuracy was .857, meaning that 72 of the 84 employees in the test sample were correctly classified. Specifically, the model correctly identified 17 of the 21 employees with high innovative work behavior and correctly rejected 55 of the 63 employees in the non-high category. Only four highly innovative employees were incorrectly classified as non-high, while eight employees in the non-high category were incorrectly classified as highly innovative. These classifications resulted in a sensitivity of .810, specificity of .873, precision of .680, F1 score of .739, and balanced accuracy of .841. The relatively small reduction from cross-validation accuracy (.871) to independent test accuracy (.857), together with similarly stable values for sensitivity, specificity, and ROC-AUC, suggested that the model generalized adequately to previously unseen observations and showed no indication of severe overfitting.

The independent test results also indicated that specificity was somewhat higher than sensitivity. The SVM classifier was therefore slightly more effective at ruling out employees who did not display exceptionally high innovative work behavior than at identifying every employee who belonged

to the high-innovation group. Nevertheless, sensitivity remained above .80, which indicated that the model detected more than four fifths of genuinely high innovative employees in the holdout sample. The lower precision of .680 relative to specificity reflected the comparatively low prevalence of the positive class generated by the upper-quartile classification criterion. In practical terms, 17 of the 25 employees predicted by the classifier to have high innovative work behavior were true positive cases, while eight represented false-positive predictions. Considering that only one quarter of the sample belonged to the positive class, the combination of sensitivity, specificity, balanced accuracy, and ROC-AUC provided stronger evidence of predictive usefulness than overall accuracy considered in isolation.

Table 3

Permutation-Based Importance of Psychological and Organizational Predictors in the Final SVM Model

Rank	Predictor	Mean Decrease in Balanced Accuracy	SD
1	Creative self-efficacy	.082	.014
2	Organizational climate for innovation	.069	.013
3	Psychological capital	.058	.011
4	Work engagement	.046	.010
5	Knowledge sharing	.040	.009
6	Job autonomy	.034	.008
7	Intrinsic work motivation	.029	.008
8	Perceived organizational support	.024	.007
9	Perceived supervisor support	.017	.006

As indicated in Table 3, creative self-efficacy emerged as the most influential predictor in the SVM classification model. Random permutation of creative self-efficacy produced an average reduction of .082 in balanced accuracy, demonstrating that the model relied substantially on employees' confidence in their capacity to generate and implement creative solutions when separating highly innovative employees from other employees. Organizational climate for innovation ranked second, with a mean reduction in balanced accuracy of .069, suggesting that employees' perception of an organizational environment that supports new ideas, experimentation, and innovation was a major organizational discriminator of high innovative work behavior. Psychological capital ranked third, with a decrease of .058, indicating that the combined psychological resources of efficacy, hope, resilience, and optimism provided considerable information for classification. Work engagement was the fourth most influential predictor, with an importance value of .046, followed by knowledge sharing at .040. These findings suggest that sustained energetic

To clarify which predictors contributed most strongly to the classification of employees with high innovative work behavior, permutation-based feature importance was calculated using the fitted SVM model. Each feature was repeatedly permuted while all remaining predictors were retained in their original form, and the consequent reduction in balanced classification accuracy was calculated. Because the radial basis function SVM represents nonlinear decision boundaries and does not produce directly interpretable standardized regression coefficients, permutation importance provided a model-appropriate indication of the predictive contribution of each psychological and organizational characteristic. Larger reductions in balanced accuracy indicated greater dependence of the classifier on the corresponding feature.

involvement in work and active exchange of knowledge with colleagues provided additional information for distinguishing highly innovative employees. Job autonomy produced an importance value of .034, whereas intrinsic work motivation showed an importance value of .029. Perceived organizational support and perceived supervisor support produced smaller, although still positive, decreases in classification performance of .024 and .017, respectively. Thus, all nine predictors contributed useful information to some extent, but their relative predictive contribution was not equivalent. The strongest classification information was concentrated in creative self-efficacy, organizational climate for innovation, psychological capital, and work engagement, suggesting that high innovative work behavior was most clearly characterized by a combination of employees' perceived creative capability, positive psychological resources, energetic engagement with their work, and an organizational environment conducive to innovation.

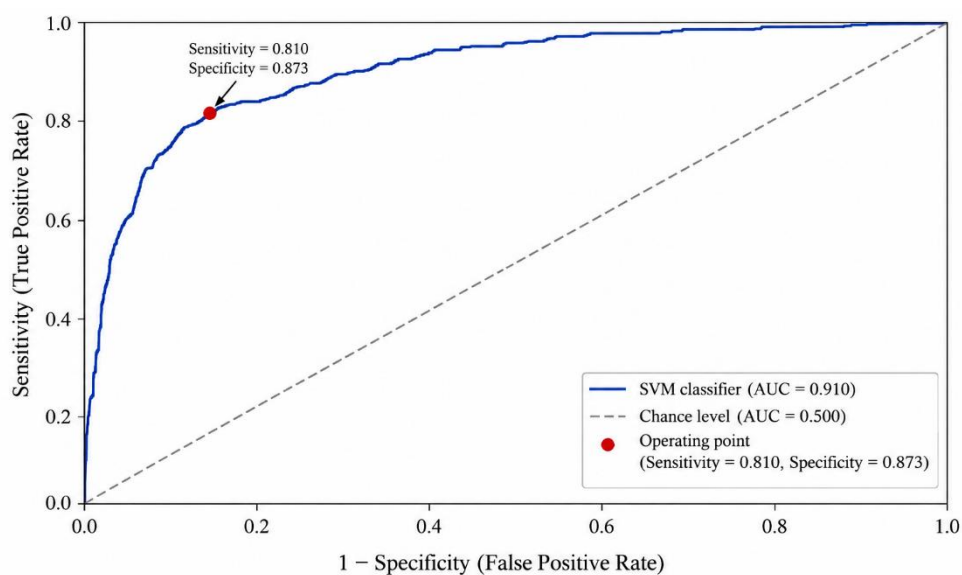
Importantly, the feature-importance ranking should not be interpreted in the same manner as coefficients from a

linear regression model. The SVM classifier was designed to identify an optimal multivariate boundary between employee classes, and the contribution of an individual predictor could depend on its interaction with other psychological and organizational features. Thus, a comparatively lower permutation-importance score did not indicate that a variable was unrelated to innovative work behavior. For example, perceived supervisor support demonstrated a significant zero-order correlation with innovative work behavior in Table 1 despite ranking ninth in

the permutation analysis. This pattern indicates that part of the predictive information contained in supervisor support may overlap with information represented by broader organizational climate or organizational support measures. In contrast, creative self-efficacy retained the largest unique contribution to classification performance when the trained model was disrupted one predictor at a time, providing evidence of its central role in distinguishing employees exhibiting particularly high levels of innovative work behavior.

Figure 1

Receiver Operating Characteristic Curve of the Support Vector Machine Classifier for High Innovative Work Behavior



The receiver operating characteristic analysis demonstrated strong discrimination by the final SVM classifier. The area under the ROC curve in the independent test sample was .910, indicating a high probability that the model would assign a higher decision score to a randomly selected employee with high innovative work behavior than to a randomly selected employee from the non-high innovative work behavior group. The curve therefore remained substantially above the chance-level diagonal across the relevant range of classification thresholds. At the operating threshold used for the final classification, sensitivity was .810 and specificity was .873, demonstrating a favorable balance between detection of highly innovative employees and correct exclusion of employees who did not meet the high innovative work behavior criterion. The high AUC was particularly important given the unequal class distribution, because it demonstrated that the predictive performance of the model was not simply a consequence of

the larger number of employees in the non-high category. Rather, the classifier displayed meaningful discriminatory capacity across thresholds independent of a single cutoff.

Overall, the findings supported the capacity of psychological and organizational indicators to differentiate employees with particularly high innovative work behavior. The final radial basis function SVM correctly classified 85.7% of previously unseen employees and achieved a balanced accuracy of 84.1%, while preserving sensitivity above 80% and specificity above 87%. The ROC-AUC of .910 further demonstrated excellent overall discrimination. Among the predictors, creative self-efficacy provided the greatest contribution to classification, followed by organizational climate for innovation, psychological capital, and work engagement. Knowledge sharing, job autonomy, and intrinsic work motivation provided additional predictive information, while perceived organizational support and perceived supervisor support made smaller but still useful

contributions. Collectively, these findings demonstrate that employees with high innovative work behavior can be differentiated with substantial accuracy by integrating individual psychological resources with perceptions of the organizational environment rather than relying on a single explanatory characteristic.

The explainability analysis also revealed that conventional demographic variables were substantially less influential than organizational and human resource factors. Age, gender, educational level, marital status, and employment sector did not appear among the highest-ranked global predictors once attitudinal, behavioral, and HR-related features were simultaneously considered by the XGBoost model. Organizational tenure showed a modest predictive contribution, with shorter tenure tending to increase turnover-intention predictions, but its mean absolute SHAP value remained substantially below those of job satisfaction, organizational commitment, stress, and career-development opportunities. Weekly working hours also exerted a comparatively modest global influence; nevertheless, particularly long working schedules generally shifted predictions toward higher turnover intention. These findings indicated that while structural and employment characteristics contributed incremental information, the strongest predictive signals were derived from employees' lived experiences within their organizations.

Overall, the findings demonstrated that the XGBoost model provided both strong predictive performance and substantively interpretable results. The independent test ROC-AUC of 0.88 indicated that the model could effectively discriminate employees with high versus low turnover intention, while the SHAP results clarified which variables were responsible for these predictions. Job satisfaction and organizational commitment emerged as the dominant protective factors, whereas work-related stress represented the strongest risk-enhancing feature. Career advancement opportunities, perceived organizational support, work-life balance, compensation satisfaction, leadership quality, recognition and rewards, and perceived HR fairness also made substantial contributions. The convergence between predictive importance and theoretically meaningful organizational factors indicates that explainable machine learning can provide more than classification accuracy alone; it can reveal actionable combinations of workplace conditions associated with employees' intention to remain with or leave their organizations.

4 Discussion

The present study investigated whether employees with high innovative work behavior could be accurately classified using psychological and organizational indicators through a Support Vector Machine model. The findings demonstrated that the selected indicators provided substantial predictive information for distinguishing employees with particularly high innovative work behavior from other employees. The optimized radial basis function SVM achieved an accuracy of .857, balanced accuracy of .841, sensitivity of .810, specificity of .873, precision of .680, F1 score of .739, and an ROC-AUC of .910 in the independent test sample. These results indicate that the classification model performed well not only in terms of overall accuracy but also in differentiating the minority group of highly innovative employees from the substantially larger comparison group. The relatively small difference between cross-validation accuracy and independent test accuracy additionally suggested satisfactory generalizability and limited evidence of serious overfitting. From a substantive perspective, the findings support the assumption that high innovative work behavior is not attributable to a single employee characteristic but can be more effectively understood as the product of a configuration of psychological resources and organizational conditions.

The strong overall classification performance is consistent with contemporary perspectives describing innovative work behavior as a multidimensional outcome shaped by interactions between individual and contextual determinants. Prior research has repeatedly shown that innovation at work develops through combinations of employee motivation, psychological empowerment, engagement, leadership, organizational support, knowledge exchange, and climate conditions rather than through isolated predictors (Caroline et al., 2025; Waheed & Khan, 2025). The present findings extend this literature by demonstrating that these types of indicators are not merely statistically associated with innovative behavior but can be integrated into a predictive model capable of identifying employees with particularly high levels of innovative work behavior. This distinction is important because predictive classification evaluates whether a pattern identified in one portion of the data can be generalized to previously unseen employees. The high ROC-AUC of .910 suggests excellent discriminatory capacity and indicates that the model captured a meaningful multivariate pattern separating highly innovative employees from their counterparts.

Creative self-efficacy emerged as the most important predictor in the model, producing the largest reduction in balanced accuracy when permuted. This finding is theoretically plausible because innovative work behavior begins with employees' willingness to approach problems creatively, generate novel ideas, and believe that they can successfully manage tasks requiring originality. Employees with high creative self-efficacy are more likely to interpret challenging work situations as opportunities for innovation rather than as threats, and they may be more persistent when their ideas encounter uncertainty or resistance. The present result is strongly aligned with research showing that creative self-efficacy functions as a psychological mechanism through which entrepreneurial leadership enhances innovative work behavior (Takeed et al., 2025). It is also compatible with evidence emphasizing the contribution of creativity to innovative behavior in technology-rich contexts, including situations in which artificial intelligence provides resources that employees must transform into meaningful innovative output (Andayesh, 2025). Similarly, research on digital leadership has shown that creativity, proactive personality, and work engagement jointly contribute to innovative work behavior (Siregar et al., 2026). Taken together, these findings suggest that confidence in one's creative capability is not a peripheral characteristic but may represent a central psychological condition for sustained innovative action.

Organizational climate for innovation was the second most important predictor, highlighting the critical role of the work environment in facilitating or constraining employee innovation. Innovative behavior can expose employees to uncertainty, interpersonal disagreement, and the possibility that new ideas will be rejected. Under such circumstances, employees are more likely to innovate when they perceive that experimentation, new ideas, constructive risk taking, and learning are encouraged rather than punished. The strong predictive contribution of innovation climate in the present study is consistent with findings showing that organizational climate can mediate the influence of transformational and shared leadership on innovative work behavior (Hamidah & Antonio, 2025). It is also supported by evidence that collaborative workplace atmospheres are positively related to innovative behavior because they create conditions for interaction, information exchange, and shared problem solving (Liu & Sun, 2025). The current findings therefore reinforce the view that individual willingness to innovate is strongly influenced by employees' interpretation

of whether their organizational environment genuinely permits innovation.

Psychological capital ranked third in predictive importance. Psychological capital incorporates positive psychological resources such as self-efficacy, hope, resilience, and optimism, each of which may be particularly relevant to innovation because innovative efforts rarely proceed without setbacks. Employees attempting to implement new ideas may experience criticism, resource constraints, delayed outcomes, or implementation failure. Psychological resources that sustain goal-directed effort and recovery from setbacks may therefore help employees continue innovative activities despite organizational obstacles. Although the cited studies did not uniformly examine psychological capital as a single construct, the broader pattern of evidence is consistent with its importance. Research has demonstrated that psychological empowerment plays a major role in transmitting the effects of talent management to innovative work behavior (Sanusi et al., 2025), while other studies have shown that psychological empowerment mediates the relationship between transformational leadership and innovation (Vu et al., 2025). These findings collectively indicate that employees' internal psychological resources form an essential part of the pathway through which favorable organizational conditions are converted into innovative behavior.

Work engagement was the fourth most important predictor and also showed a strong positive correlation with innovative work behavior. This finding can be interpreted through the energetic and motivational demands of innovation. Innovative behavior requires employees to allocate attention beyond routine task completion, identify opportunities for improvement, generate ideas, communicate with others, and persist in implementation. Such activities require vigor, dedication, and sustained cognitive involvement. The result is consistent with evidence showing that perceived high-performance work systems promote innovative work behavior through work engagement (Husin et al., 2025). It also aligns with findings indicating that transformational leadership influences innovative work behavior through both psychological empowerment and work engagement (Vu et al., 2025). Research involving teachers similarly demonstrates that work engagement contributes to innovative behavior within a broader network of digital leadership, creativity, and proactive personality (Siregar et al., 2026). The present results therefore support the interpretation that engaged

employees are more likely to invest discretionary psychological energy in innovation because they are cognitively and emotionally connected to their work.

Knowledge sharing ranked fifth and contributed meaningful predictive information. Innovation is often portrayed as an individual creative achievement, but organizational innovation is usually embedded in social interaction. Employees develop ideas from existing knowledge, improve them through feedback, and implement them through cooperation with others. Knowledge sharing therefore increases exposure to alternative perspectives, technical expertise, and practical experience that can stimulate new combinations of information. The current finding agrees with evidence demonstrating that interpersonal communication and knowledge sharing are important determinants of innovative work behavior (Munawaroh et al., 2025). It is also consistent with research showing that sharing-oriented workplace relationships can support innovation through psychological empowerment and employee engagement (Marampa et al., 2025). The predictive importance of knowledge sharing in the present model suggests that highly innovative employees may be distinguished not only by what they know individually but also by how actively they participate in organizational knowledge exchange.

Job autonomy also contributed to classification performance. Autonomy gives employees discretion over how they approach tasks, organize work processes, and respond to emerging problems. Such discretion may be essential for innovation because rigid procedures can restrict experimentation and limit employees' capacity to implement unconventional solutions. The importance of autonomy is indirectly supported by research emphasizing employee participation and empowering organizational practices. For example, green human resource management has been linked to green innovative work behavior through mechanisms involving employee participation (Piwowar-Sulej & Iqbal, 2025), while empowering leadership has been associated with innovative behavior through professional development (Ghanbari & Norouzi, 2025). Talent management has also been connected to innovative work behavior through psychological empowerment, which includes an important self-determination component (Sanusi et al., 2025). These findings support the present result by indicating that employees are more likely to innovate when organizational structures provide room for initiative, participation, and independent decision-making.

Intrinsic work motivation ranked below job autonomy but nevertheless provided additional predictive information. Innovation often requires effort that is not immediately rewarded and may extend beyond formal job descriptions. Employees who experience their work as interesting, meaningful, and personally satisfying may therefore be more willing to engage in exploratory behavior without relying exclusively on external incentives. The result is compatible with research showing that transformational leadership can foster movement from idea exploration to implementation by creating conditions that encourage employee involvement and initiative (Phairat et al., 2026). It is also consistent with studies demonstrating the importance of engagement and psychological empowerment as motivational mechanisms in innovative work behavior (Husin et al., 2025; Vu et al., 2025). The present findings imply that intrinsic motivation contributes to innovation, although its predictive contribution may partly overlap with work engagement, psychological capital, and autonomy.

Perceived organizational support and perceived supervisor support ranked eighth and ninth, respectively, in the permutation analysis, although both showed significant positive correlations with innovative work behavior. This combination of findings is important. Their lower feature-importance values should not be interpreted as evidence that support is irrelevant; rather, it may indicate that some of the information they provide is shared with broader contextual variables such as organizational climate, job autonomy, and engagement. Organizational support has been linked to innovative work behavior and to broader organizational outcomes such as business model innovation (Hock-Doepgen et al., 2025). Leadership studies also consistently indicate that supportive leadership environments can strengthen employee innovation. Ambidextrous leadership has been associated with innovative work behavior in healthcare settings (Attique et al., 2025), transformational leadership has been linked to innovation through psychological empowerment and engagement (Vu et al., 2025), and empowering leadership has been associated with innovative behavior through professional development (Ghanbari & Norouzi, 2025). Thus, supervisor and organizational support may form part of a wider innovation-supportive system whose influence is partially represented by other variables in the multivariate classifier.

The stronger predictive importance of organizational climate compared with perceived organizational and supervisor support may indicate that employees respond not only to direct supportive relationships but also to broader

signals concerning whether innovation is institutionally accepted. An employee may receive encouragement from a supervisor, but sustained innovative behavior is more likely when organizational routines, norms, resource allocation, collaboration patterns, and evaluation systems consistently support innovation. This interpretation is compatible with research linking collaborative climate to innovative work behavior (Liu & Sun, 2025) and with findings showing that organizational climate mediates leadership effects among employees in creative industries (Hamidah & Antonio, 2025). It also corresponds with the wider HRM literature suggesting that innovation is strengthened when organizational systems collectively provide development opportunities, flexibility, participation, and supportive performance conditions (Husin et al., 2025; Masoudnia & Nasti Zayi, 2025).

The findings also align with broader evidence regarding the role of human resource systems in creating the conditions required for innovative behavior. Human resource flexibility has been identified as a mechanism linking HRM actions with innovative work behavior (Masoudnia & Nasti Zayi, 2025), while green HRM practices have been shown to promote forms of innovative behavior directed toward environmental objectives (Khan et al., 2025). Similarly, employee participation has been emphasized as a pathway through which HRM practices can stimulate green innovative work behavior (Piwowar-Sulej & Iqbal, 2025). These studies support the central implication of the current classification model: high innovative work behavior is more likely to emerge where individual psychological capacity is accompanied by organizational systems that provide flexibility, opportunity, participation, and support. The SVM model effectively captured this combination because its strongest predictors represented both sides of this relationship—creative self-efficacy and psychological capital at the individual level, and organizational climate and knowledge sharing at the contextual level.

The present findings are also relevant to research across professional sectors. Innovative work behavior has been examined among teachers, healthcare professionals, banking employees, hospitality workers, creative-industry employees, and service-sector personnel, suggesting that innovation is a cross-sector organizational phenomenon (Attique et al., 2025; Aziz, 2025; Bui et al., 2025; Khan et al., 2025). Research on professional development among teachers has emphasized the importance of developing innovative capabilities through structured developmental strategies (Ramezani & Mirkazemi, 2025). Studies

involving service workers have similarly connected innovative behavior with sustainability-related development (Yusriani et al., 2025). The findings from Tunisian employees therefore contribute to this broader literature by showing that a combination of psychological and organizational indicators can discriminate high innovative work behavior within a North African organizational context. This expands the geographical range of the literature and suggests that the psychological-organizational architecture of innovation may have relevance across different institutional environments.

Another important aspect of the results concerns the balance between sensitivity and specificity. The classifier correctly identified 81.0% of employees with high innovative work behavior and 87.3% of employees in the non-high category. The somewhat higher specificity indicates that the model was slightly better at correctly excluding employees who did not meet the high-innovation criterion than at detecting every highly innovative employee. This result is understandable given that the high innovative work behavior group represented only approximately one quarter of the sample. Despite this imbalance, balanced accuracy remained .841 and ROC-AUC reached .910, suggesting that the model did not simply favor the majority class. The precision of .680 was lower than sensitivity and specificity, meaning that some employees predicted to belong to the high-innovation group were false-positive cases. From an organizational perspective, this finding reinforces the importance of using predictive classification as a probabilistic decision-support approach rather than treating algorithmic classifications as definitive judgments regarding employee capability.

5 Conclusion

Overall, the results support an integrated interpretation of innovative work behavior in which psychological capability and organizational opportunity operate together. Creative self-efficacy emerged as the strongest discriminator, but it functioned within a wider configuration that included organizational climate, psychological capital, engagement, knowledge sharing, autonomy, intrinsic motivation, and support. This pattern corresponds with contemporary research emphasizing that innovative work behavior reflects the interaction of leadership, employee motivation, social exchange, HRM practices, development opportunities, and organizational conditions (Caroline et al., 2025; Waheed & Khan, 2025). It is also consistent with evidence suggesting

that innovative work behavior contributes to organizationally relevant outcomes, including performance and business model innovation (Bui et al., 2025; Hock-Doeppen et al., 2025). The present study adds a predictive dimension to this literature by demonstrating that these indicators can be integrated through nonlinear machine learning to classify highly innovative employees with substantial out-of-sample accuracy.

The present study has several limitations that should be considered when interpreting the findings. First, the cross-sectional design does not permit causal conclusions regarding whether psychological and organizational indicators lead to innovative work behavior or whether highly innovative employees subsequently develop more favorable perceptions of their work environments. Second, most variables were assessed through self-report questionnaires, creating the possibility of common-method variance, social desirability, and subjective response bias. Third, although participants were recruited from several Tunisian cities and organizational sectors, the sample cannot be assumed to represent the entire Tunisian workforce. Fourth, high innovative work behavior was operationalized using an upper-quartile cutoff, which provided a clear classification target but necessarily simplified a continuous behavioral construct. Fifth, although the independent test set provided an important assessment of out-of-sample performance, external validation using an entirely separate organizational sample was not conducted. Finally, permutation importance indicates the contribution of predictors to model performance but does not establish causal effects or provide the same form of interpretation as conventional regression coefficients.

Future research should employ longitudinal designs to examine how changes in psychological resources and organizational conditions predict later changes in innovative work behavior. Replication using larger samples from different regions of Tunisia and other North African countries would help establish the external validity and cultural generalizability of the model. Future studies should also incorporate supervisor ratings, peer ratings, objective innovation outcomes, or organizational records to complement self-reported innovative behavior. Alternative operational definitions of high innovative work behavior could be compared, including theoretically established scale thresholds, latent-profile approaches, and repeated behavioral indicators. Researchers should additionally compare SVM performance with other machine-learning algorithms such as random forests, gradient boosting,

regularized logistic regression, and neural networks using identical cross-validation and test procedures. Explainability techniques such as SHAP values or accumulated local effects could further clarify nonlinear relationships and interactions among predictors. Longitudinal machine-learning models could also be used to determine whether employees move between innovation profiles over time and which organizational interventions are associated with such transitions.

From a practical perspective, organizations should use the present findings primarily to guide employee development and work-environment design rather than to create rigid labels of “innovative” and “non-innovative” employees. Human resource managers can prioritize programs that strengthen creative confidence, resilience, hope, work engagement, intrinsic motivation, and employees’ sense of autonomy. Managers should also create an organizational climate in which proposing unconventional ideas is psychologically safe, experimentation is encouraged, reasonable failure is treated as a learning opportunity, and employees have realistic opportunities to implement promising suggestions. Knowledge-sharing systems, interdisciplinary teamwork, mentoring, internal innovation forums, and collaborative problem-solving activities can strengthen the social conditions that support innovation. Supervisors should provide timely feedback and practical support while avoiding excessive control that restricts initiative. Predictive models may be used at an aggregate level to identify organizational conditions requiring improvement, but employee-level algorithmic outputs should not be used as the sole basis for selection, promotion, or performance evaluation. The greatest practical value of the findings lies in showing that innovative behavior can be cultivated by simultaneously strengthening employee psychological resources and the organizational conditions that allow those resources to be translated into action.

Authors’ Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

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