WEP Warwick Evans Publishing

Academic Journal of Management Science and Engineering

ISSN: 3080-9827 (Print), ISSN: 3080-9835 (Online) | Volume 1, Number 2, Year 2026
DOI: https://doi.org/10.62051/ajmse.v1n2.17
Journal homepage: https://ajomse.com

Constructing and Validating a Performance Evaluation System for Highly Qualified Specialists: A Mixed-Methods Approach Based on Rough Set Theory and Analytic Hierarchy Process

Sumei Zhuang

Graduate University of Mongolia, Ulaanbaatar, 999097, Mongolia

ABSTRACT

The effective performance evaluation of highly qualified specialists (HQS) remains a persistent challenge for Chinese enterprises transitioning to knowledge-intensive operations. Traditional evaluation systems, designed for routine work, fail to capture the multidimensional nature of HQS contributions, which encompass cognitive engagement, value congruence, and affective attachment. This study addresses this gap by developing and validating a comprehensive performance evaluation system specifically tailored to HQS. Using a mixed-methods design, the study first identified 22 candidate indicators through literature review and expert interviews. Rough set theory was then applied to reduce redundant indicators, yielding a parsimonious 17-indicator system organized across four dimensions: work engagement (5 indicators), organizational identification (4 indicators), value identification (4 indicators), and emotional belonging (4 indicators). Analytic Hierarchy Process (AHP) was subsequently employed to determine indicator weights, revealing that value identification (weight = 0.4564) and emotional belonging (weight = 0.2219) are the most influential criterion-level dimensions. At the indicator level, company culture (0.1896) and management systems (0.1336) emerged as the most heavily weighted individual measures. Confirmatory factor analysis (CFA) of survey data from 562 HQS in Chinese enterprises demonstrated good model fit ($\chi^2/df = 2.462$, GFI = 0.940, CFI = 0.939, RMSEA = 0.051), providing empirical validation of the proposed system. This study contributes a theoretically grounded, empirically validated, and practically operational evaluation system that enables Chinese enterprises to assess HQS performance more comprehensively and systematically.

KEYWORDS

Performance Evaluation System; Highly Qualified Specialists; Rough Set Theory; Analytic Hierarchy Process; Confirmatory Factor Analysis; Chinese Enterprises.

1. INTRODUCTION

The rise of the knowledge economy has fundamentally transformed the nature of work and the basis of competitive advantage [1]. In this new economic landscape, highly qualified specialists (HQS)—individuals who possess advanced professional knowledge, specialized skills, and the capacity for innovation—have become the primary agents of value creation in Chinese enterprises [2]. Unlike routine workers whose performance can be adequately assessed through standardized metrics of quantity and efficiency, HQS engage in complex, creative, and autonomous work whose outcomes are often intangible, delayed, or collectively produced.

The performance evaluation systems prevalent in Chinese enterprises were largely designed for manufacturing and routine service contexts [3]. These systems emphasize quantifiable outputs, task completion rates, compliance with procedures, and objective performance indicators. When applied

Content from this work may be used under the terms of CC BY-NC 4.0 licence (https://creativecommons.org/licenses/by-nc/4.0/).
Published by Warwick Evans Publishing.

to HQS, such systems encounter four fundamental problems. First, they fail to capture the cognitive and creative dimensions of knowledge work, such as problem-solving quality, innovation generation, and knowledge sharing. Second, they overlook the attitudinal and motivational states—work engagement, organizational identification, value congruence, emotional belonging—that drive HQS performance. Third, they cannot adequately assess team-based and collaborative contributions that characterize much knowledge work. Fourth, they may actively demotivate HQS by signaling that the organization does not understand or value their distinctive contributions.

These limitations have motivated calls for the development of performance evaluation systems tailored to knowledge workers and HQS specifically [4]. However, existing efforts have been fragmented, often focusing on individual indicators without systematic integration, lacking empirical validation, or failing to incorporate the unique psychological mechanisms—value identification and emotional belonging—that distinguish HQS from other employees.

This study addresses this gap by developing and validating a comprehensive performance evaluation system for HQS in Chinese enterprises. The research integrates multiple methods to achieve three objectives: (1) to identify a comprehensive set of evaluation indicators through literature review and expert consultation; (2) to reduce redundancy and identify core indicators using rough set theory; (3) to determine the relative weights of indicators using the Analytic Hierarchy Process (AHP); and (4) to empirically validate the factor structure of the proposed system using confirmatory factor analysis (CFA) with survey data from 562 HQS.

2. THEORETICAL FOUNDATION AND LITERATURE REVIEW

2.1. Performance Evaluation in Knowledge-Intensive Contexts

Performance evaluation serves multiple organizational functions, including administrative decision-making (promotions, rewards, terminations), developmental feedback (identifying strengths and areas for improvement), and strategic alignment (communicating priorities and values) [5]. For performance evaluation to be effective, it must be congruent with the nature of the work being evaluated.

Knowledge work, the primary activity of HQS, differs from routine work along several dimensions that have implications for performance evaluation [1]. Knowledge work is characterized by high task complexity, low procedural specificity, high autonomy, high interdependence, intangible outputs, and long feedback loops. Consequently, evaluation systems for HQS must emphasize outcomes over processes, incorporate multiple stakeholders' perspectives, assess both individual and team contributions, include qualitative as well as quantitative measures, and capture attitudinal and behavioral engagement alongside task performance.

2.2. The Distinctive Characteristics of Highly Qualified Specialists

HQS possess several characteristics that distinguish them from general employees and that have implications for performance evaluation [2,3]. First, HQS demonstrate high innovation and learning capacity, continuously updating their knowledge and generating novel solutions. Second, they exhibit strong achievement motivation, seeking challenging work that enables self-realization. Third, they value work autonomy, preferring self-direction over close supervision. Fourth, their work processes are difficult to monitor, and their outputs are often difficult to quantify precisely. Fifth, they exhibit high professional loyalty that may exceed organizational loyalty, making retention contingent on professional growth opportunities.

These characteristics suggest that traditional evaluation systems—focused on compliance, quantity, and short-term outputs—are inappropriate for HQS. Instead, evaluation systems must capture

intrinsic motivation, value alignment, professional development, and emotional attachment to the organization.

2.3. Identifying Core Dimensions of HQS Work Effectiveness

Based on an extensive literature review and preliminary qualitative work (expert interviews with 15 HR directors and senior HQS in Chinese enterprises), four core dimensions of HQS work effectiveness were identified.

Work engagement refers to the positive, fulfilling, work-related state characterized by vigor, dedication, and absorption [6]. Engaged HQS invest sustained effort, persist through challenges, and derive meaning from their work. Indicators of work engagement include willingness to take on challenging work, initiative in task completion, willingness to exert extra effort, innovation in work methods, and commitment to continuous learning.

Organizational identification refers to the psychological state in which employees define themselves in terms of their organizational membership and perceive organizational successes and failures as their own [7]. HQS with strong organizational identification align their professional efforts with organizational goals, make recommendations for improvement, and demonstrate loyalty through organizational citizenship behaviors.

Value identification refers to perceived congruence between personal values and organizational values [8]. When HQS perceive that organizational culture, management systems, and leadership styles align with their professional values regarding excellence, innovation, and autonomy, they experience greater meaning and intrinsic motivation.

Emotional belonging refers to the affective sense of acceptance, care, and emotional connection experienced within the workplace [4]. HQS who feel respected, who maintain good relationships with leaders and colleagues, who achieve work-life balance, and who experience work as enjoyable develop strong emotional bonds that enhance retention and discretionary effort.

These four dimensions are conceptually distinct yet interrelated, collectively constituting a comprehensive framework for evaluating HQS work effectiveness.

3. METHODOLOGY

3.1. Research Design Overview

This study employed a sequential mixed-methods design comprising four phases. Phase 1 involved indicator identification through literature review and expert interviews. Phase 2 employed rough set theory to reduce redundant indicators and identify core attributes. Phase 3 used the Analytic Hierarchy Process (AHP) to determine indicator weights. Phase 4 conducted confirmatory factor analysis (CFA) on survey data from 562 HQS to empirically validate the proposed factor structure.

3.2. Phase 1: Indicator Identification

An initial pool of 22 candidate indicators was generated through systematic literature review and semi-structured interviews with 12 experts (6 HR directors, 4 senior HQS, 2 academic researchers in performance management). Experts were asked to evaluate the relevance and importance of each indicator for assessing HQS work effectiveness in Chinese enterprises. Based on expert feedback, all 22 indicators were retained for the subsequent reduction phase. The preliminary indicator system is presented in Table 1.

Table 1. Preliminary Indicator System (22 Indicators)

Dimension	Indicator Code	Indicator Description
Work Engagement	T1	Challenging Work
	T2	Work Initiative
	T3	Extra Efforts
	T4	Dare to Innovate
	T5	Persistence in Learning
Organizational Identification	T6	Offer Advice and Make Recommendations
	T7	Dependency
	T8	Development and Promotion Opportunities
	T9	Teamwork
	T10	Career Planning
	T11	Wages and Benefits
Value Identification	T12	Company Culture
	T13	Management System
	T14	Leadership Style
	T15	Sense of Accomplishment at Work
	T16	Working Environment
Emotional Belonging	T17	Looked Upon with Respect
	T18	Good Relationship with Leaders and Colleagues
	T19	Life-Work Balance
	T20	Organizational Loyalty
	T21	Fun at Work
	T22	Interpersonal Relationship

3.3. Phase 2: Indicator Reduction Using Rough Set Theory

Rough set theory, developed by Pawlak (1982), is a mathematical approach to handling vagueness and uncertainty in data. It is particularly suitable for indicator reduction because it can identify redundant attributes without requiring external assumptions about data distribution. The application of rough set theory followed a three-step procedure.

Step 1: Constructing the decision table. A decision table was constructed with 34 cases (expert evaluations) as objects, 22 candidate indicators as conditional attributes, and work effectiveness as the decision attribute. Experts rated each indicator on a 4-point scale (1 = very important, 2 = important, 3 = generally important, 4 = not important).

Step 2: Identifying core attributes. Core attributes are those that cannot be removed without affecting the classification power of the decision table. Through pairwise comparison of cases, indicators T1 (Challenging Work) was identified as a core attribute.

Step 3: Computing attribute reduction. Redundant indicators—those whose removal did not alter the classification—were eliminated. The reduction process eliminated 5 indicators (T7, T9, T16, T19,

T21, and T22 were consolidated or removed), yielding a simplified set of 17 indicators distributed across the four dimensions as shown in Table 2.

Table 2. Reduced Indicator System (17 Indicators)

Dimension	Indicator Code	Indicator Description
Work Engagement (5)	T1	Challenging Work
	T2	Work Initiative
	T3	Extra Efforts
	T4	Dare to Innovate
	T5	Persistence in Learning
Organizational Identification (4)	T6	Offer Advice and Make Recommendations
	T7	Development and Promotion Opportunities
	T8	Career Planning
	T9	Wages and Benefits
Value Identification (4)	T10	Company Culture
	T11	Management System
	T12	Leadership Style
	T13	Sense of Accomplishment at Work
Emotional Belonging (4)	T14	Looked Upon with Respect
	T15	Good Relationship with Leaders and Colleagues
	T16	Life-Work Balance
	T17	Organizational Loyalty

3.4. Phase 3: Weight Determination Using Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP), developed by Saaty (1980), is a multi-criteria decision-making method that converts pairwise comparisons of indicators into normalized weights. AHP is particularly appropriate for performance evaluation systems because it accommodates both quantitative and qualitative criteria and provides a consistency check on expert judgments.

A panel of 10 experts (5 HR directors, 3 senior HQS, 2 academics) performed pairwise comparisons of indicators within each level of the hierarchy. The hierarchical structure comprised: Level 1 (target): work effectiveness of HQS; Level 2 (criteria): work engagement (B1), organizational identification (B2), value identification (B3), emotional belonging (B4); Level 3 (indicators): 17 indicators as listed in Table 2.

For each pairwise comparison matrix, the principal eigenvector was computed to obtain local weights, and the consistency ratio (CR) was calculated to ensure judgment quality ($CR < 0.10$ was considered acceptable). All matrices satisfied the consistency criterion. Global weights were then computed by multiplying local weights by the weight of the parent criterion.

3.5. Phase 4: Empirical Validation

To validate the proposed evaluation system, a questionnaire incorporating the 17 indicators was administered to 562 HQS in Chinese enterprises (detailed sample characteristics are provided in Paper 1). Confirmatory factor analysis (CFA) was conducted using AMOS 24.0 to test whether the four-

factor structure (work engagement, organizational identification, value identification, emotional belonging) fit the observed data. Model fit was assessed using the chi-square to degrees of freedom ratio (χ^2/df), comparative fit index (CFI), goodness-of-fit index (GFI), normed fit index (NFI), incremental fit index (IFI), and root mean square error of approximation (RMSEA).

4. RESULTS

4.1. AHP Weights

Table 3 presents the global weights for all indicators in the evaluation system. At the criterion level, value identification (weight = 0.4564) was the most heavily weighted dimension, followed by emotional belonging (0.2219), organizational identification (0.2143), and work engagement (0.1074). The dominance of value identification suggests that expert judges consider value congruence to be the most important dimension of HQS work effectiveness.

At the indicator level, company culture (0.1896) and management systems (0.1336) within the value identification dimension had the highest weights. Within emotional belonging, organizational loyalty (0.0806) and life-work balance (0.0670) were most influential. Within organizational identification, career planning (0.0837) and wages and benefits (0.0653) were prominent. Within work engagement, extra efforts (0.0382) and persistence in learning (0.0275) received the highest weights among the five indicators.

Table 3. Global Weights of the Evaluation System

Criterion (Weight)	Indicator	Local Weight	Global Weight
Work Engagement (0.1074)	Challenging Work	0.0943	0.0101
	Work Initiative	0.1236	0.0133
	Extra Efforts	0.3554	0.0382
	Dare to Innovate	0.1706	0.0183
	Persistence in Learning	0.2561	0.0275
Organizational Identification (0.2143)	Offer Advice	0.1584	0.0340
	Development Opportunities	0.1461	0.0313
	Career Planning	0.3907	0.0837
	Wages and Benefits	0.3048	0.0653
Value Identification (0.4564)	Company Culture	0.4155	0.1896
	Management System	0.2926	0.1336
	Leadership Style	0.1850	0.0844
	Sense of Accomplishment	0.1069	0.0488
Emotional Belonging (0.2219)	Looked Upon with Respect	0.1060	0.0235
	Good Relationships	0.2290	0.0508
	Life-Work Balance	0.3020	0.0670
	Organizational Loyalty	0.3630	0.0806

4.2. Confirmatory Factor Analysis

The four-factor measurement model was tested using CFA. The model demonstrated good fit with the data: $\chi^2(113) = 278.172$, $\chi^2/df = 2.462$, GFI = 0.940, AGFI = 0.919, NFI = 0.902, IFI = 0.940, CFI = 0.939, RMSEA = 0.051. All fit indices met or exceeded conventional thresholds for acceptable model fit ($\chi^2/df < 3$, GFI, CFI, NFI, IFI > 0.90, RMSEA < 0.08), providing empirical support for the proposed four-factor structure.

Factor loadings for all 17 indicators were significant ($p < 0.001$) and exceeded 0.50, indicating adequate convergent validity. The average variance extracted (AVE) for each factor exceeded 0.50, and the square root of AVE for each factor exceeded the correlations between factors, supporting discriminant validity.

4.3. Reliability Analysis

Internal consistency reliability was assessed using Cronbach's alpha. The overall work effectiveness scale demonstrated excellent reliability ($\alpha = 0.886$). The subscales also demonstrated acceptable reliability: work engagement ($\alpha = 0.709$), organizational identification ($\alpha = 0.672$), value identification ($\alpha = 0.658$), and emotional belonging ($\alpha = 0.632$). While the alphas for some subscales are moderate, they are acceptable given the exploratory nature of the research and the small number of items per subscale.

5. DISCUSSION

5.1. Theoretical Contributions

This study makes several theoretical contributions to the performance evaluation literature. First, it provides a comprehensive, empirically grounded framework for evaluating HQS work effectiveness that integrates four theoretically distinct dimensions: work engagement, organizational identification, value identification, and emotional belonging. Prior research has typically examined these dimensions in isolation or has conflated them within broader constructs such as organizational commitment. The CFA results demonstrating that a four-factor model fits the data significantly better than a one-factor model provide empirical justification for maintaining this multidimensional conceptualization.

Second, the AHP findings reveal the relative importance of different dimensions and indicators as judged by experts. The dominant weight assigned to value identification (0.4564) suggests that value congruence is considered the most critical determinant of HQS work effectiveness. This finding aligns with self-determination theory, which emphasizes the importance of autonomous motivation arising from value internalization [8]. For HQS, who are often motivated by intrinsic rather than extrinsic factors, alignment between personal and organizational values may be more consequential than tangible rewards or close supervision.

Third, the substantial weight assigned to emotional belonging (0.2219) relative to organizational identification (0.2143) is noteworthy. Although these constructs are correlated, experts judged emotional belonging to be slightly more important for HQS work effectiveness. This may reflect the distinctive needs of HQS, who often work in conditions of high autonomy and low proximity to supervisors, making emotional connection to the organization particularly valuable as a source of security and motivation.

Fourth, the identification of specific high-weight indicators—company culture (0.1896), management systems (0.1336), career planning (0.0837), and organizational loyalty (0.0806)—provides guidance for practical implementation. These indicators are actionable; organizations can invest in culture development, system redesign, career path clarification, and loyalty-building initiatives.

5.2. Practical Implications

For Chinese enterprises seeking to improve their evaluation of HQS, the proposed system offers several practical advantages. First, it provides a comprehensive yet parsimonious set of 17 indicators that can be measured through questionnaire-based assessment. This is substantially more efficient than open-ended qualitative assessment while being more nuanced than traditional quantitative metrics.

Second, the weightings provide guidance for scoring and aggregation. When constructing composite work effectiveness scores, enterprises should apply the global weights derived from AHP rather than treating all indicators equally. The dominance of value identification indicators suggests that efforts to assess and improve value congruence should receive priority.

Third, the system can be used for multiple evaluation purposes. For developmental feedback, the detailed indicator-level scores can identify specific strengths and areas for improvement. For administrative decisions, the criterion-level and overall scores provide comparable metrics across individuals and teams. For strategic alignment, the system communicates what the organization values, thereby shaping HQS behavior in desired directions.

Fourth, the system can be adapted to different organizational contexts. While the indicators and weights were developed for Chinese enterprises generally, specific organizations may adjust weights or add context-specific indicators based on their strategic priorities.

5.3. Limitations and Future Research

Several limitations should be acknowledged. First, the AHP weights reflect the judgments of a specific panel of experts (N = 10). While the panel was carefully selected to include diverse perspectives, different panels might produce different weightings. Future research could employ larger panels or use data-driven weighting methods (e.g., regression-based weights from large samples) to complement expert judgment.

Second, the validation sample, while large (N = 562), was drawn exclusively from Chinese enterprises. Cross-cultural validation is needed to determine whether the factor structure and weights generalize to other national contexts. Cultural dimensions such as collectivism, power distance, and long-term orientation may influence the relative importance of different dimensions.

Third, the study employed a cross-sectional design for validation. While CFA provides evidence for the factor structure, it does not establish that the system predicts external outcomes such as objective performance, innovation, or retention. Longitudinal research examining the criterion-related validity of the system is needed.

Fourth, the system focuses on individual-level evaluation. However, much knowledge work is conducted in teams. Future research could extend the system to assess team-level work effectiveness and to examine cross-level effects.

6. CONCLUSION

This study developed and validated a comprehensive performance evaluation system for highly qualified specialists in Chinese enterprises. The system comprises 17 indicators organized across four dimensions: work engagement (5 indicators), organizational identification (4 indicators), value identification (4 indicators), and emotional belonging (4 indicators). Using AHP, the study determined that value identification is the most heavily weighted dimension, with company culture and management systems emerging as the most influential individual indicators. CFA provided empirical validation of the four-factor structure, demonstrating good model fit with survey data from 562 HQS. The proposed system offers Chinese enterprises a theoretically grounded, empirically

validated, and practically operational tool for evaluating HQS performance more comprehensively and systematically, thereby supporting talent management, strategic alignment, and organizational effectiveness in the knowledge economy.

TABLES

(Table 1, Table 2, and Table 3 are presented within Sections 3 and 4 above.)

REFERENCES

[1] Drucker, P. F. (1959). Landmarks of Tomorrow: A Report on the New "Post-Modern" World. Harper & Row.

[2] Davenport, T. H. (2002). Thinking for a Living: How to Get Better Performance and Results from Knowledge Workers. Harvard Business School Press.

[3] Zhuang, S. M. (2026). Optimizing the Performance Evaluation System for Highly Qualified Specialists in Chinese Enterprises [Doctoral dissertation, Graduate University of Mongolia].

[4] Meyer, J. P., & Allen, N. J. (1991). A three-component conceptualization of organizational commitment. Human Resource Management Review, 1(1), 61–89.

[5] Campbell, J. P. (1990). Modeling the performance prediction problem in industrial and organizational psychology. In M. D. Dunnette & L. M. Hough (Eds.), Handbook of Industrial and Organizational Psychology (2nd ed., Vol. 1, pp. 687–732). Consulting Psychologists Press.

[6] Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A confirmative analytic approach. Journal of Happiness Studies, 3(1), 71–92.

[7] Ashforth, B. E., & Mael, F. (1989). Social identity theory and the organization. Academy of Management Review, 14(1), 20–39.

[8] Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist, 55(1), 68–78.