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IMPACT OF HUMAN RESOURCE TRAINING ON SUPPLY CHAIN EFFICIENCY IN GUIYANG'S ENTERPRISES: A STRUCTURAL EQUATION MODELLING (SEM) ANALYSIS

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ABSTRACT

This study investigates the impact of human resource (HR) training on supply chain efficiency (SCE) among enterprises in Guiyang, China. A quantitative approach was used to analyse data from 316 respondents across ten key industrial sectors. Structural equation modelling (SEM) was applied to analyse the relationships between HR training, organisational culture, technological adaptability, and supply chain efficiency. The measurement model demonstrated adequate convergent validity (average variance extracted > 0.50) and internal consistency (composite reliability > 0.70). Discriminant validity was confirmed through the Fornell-Larcker criterion and HTMT ratio (< 0.85). The structural model revealed a positive influence of HR training on organisational culture ($\beta = 0.664$, $p < 0.01$), technological adaptability ($\beta = 0.399$, $p < 0.01$), and SCE made directly ($\beta = 0.262$, $p < 0.05$) and indirectly through organisational culture and technological adaptability ($\beta = 0.272$, $p < 0.05$). The model fit indices ($\chi^2/df = 1.295$; CFI = 0.984; TLI = 0.976; RMSEA = 0.031) confirmed its robustness. The findings suggest that HR training enhances SCE by improving employee skills, fostering technological integration, and cultivating an adaptive organisational culture. This research contributes to the theoretical understanding of HR development in supply chain management. It provides policymakers and business leaders with practical insights on leveraging workforce training as a strategic tool to enhance supply chain performance in regions such as Guiyang.

KEY WORDS

human resource training, organisational culture, technological adaptability, supply chain efficiency, structural equation modelling (SEM)

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INTRODUCTION

Supply chain efficiency (SCE) has become a critical determinant of enterprise success in an era of globalisation and digital disruption, where firms must optimise costs, reduce lead times, and ensure

resilience against market volatility (Christopher, 2016; Bowersox et al., 2020; Sakharina et al., 2020). In China, particularly in emerging industrial centres like Guiyang, SCE is essential for driving regional economic growth amid rapid modernisation and integration into global value chains (Govindan et al., 2020). However, the human dimension - specifically,

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how human resource (HR) training influences SCE - remains a pressing issue. While technological and infrastructural investments dominate discussions, the role of workforce development in enhancing or undermining efficiency raises key questions: does HR training foster sustainable operational gains or does it risk creating inefficiencies if not correctly aligned with organisational factors? In transitional economies, skill mismatches that lead to supply chain bottlenecks and other high-profile challenges underscore these concerns, prompting debates over whether HR initiatives promote mutual benefits or exacerbate vulnerabilities (Sanders, 2016; Zhu et al., 2023).

Existing research highlights controversies surrounding the impact of HR training on SCE. On one hand, proponents argue that targeted training builds adaptive skills, enabling better process coordination and innovation, as seen in studies linking employee development to improved lean practices and digital integration (Gunasekaran et al., 2015; Fu et al., 2023). For instance, in manufacturing contexts, HR programmes have been credited with boosting productivity and reducing waste, mirroring benefits in broader resource management frameworks (Huo et al., 2021). On the other hand, critics contend that without supportive mechanisms, training can lead to misallocated resources or underutilised capabilities, akin to “inefficiency trap” scenarios in strategic investments where initial gains give way to long-term strains (Queiroz et al., 2019; Hasan et al., 2022). Cases from developing regions, where firms face cultural resistance or technological gaps, illustrate these tensions, though some attribute failures to pre-existing weaknesses rather than training itself (Lee & Park, 2024; Song et al., 2021).

Despite these insights, prior studies exhibit notable shortcomings, often treating HR training in isolation from mediating factors such as organisational culture and technological adaptability, thereby limiting a comprehensive understanding of its pathways to SCE (Tripathi & Talukder, 2020; Zen et al., 2023). This oversight is especially evident in regional contexts like Guiyang, where empirical evidence on human-centric drivers remains scarce amid industrial transitions. To address these gaps, this study examines the influence of HR training on SCE in Guiyang enterprises, identifies mediating mechanisms, such as organisational culture and technological adaptability, and offers policy insights to optimise HR strategies in regional supply chains. Specifically, it investigates the impact of HR training on SCE in Guiyang, how organisational culture and technological adaptability mediate this relationship, and what recommendations can enhance

HR-SCE synergies for stakeholders. Employing structural equation modelling (SEM) on data from 316 respondents across ten firms, the analysis provides regionally grounded evidence (Alrazehi et al., 2025; Silic et al., 2020).

This paper makes two key contributions to existing literature. First, it applies a structural equation modelling (SEM) framework to examine the mediating roles of organisational culture and technological adaptability in the relationship between HR training and SCE in Guiyang’s enterprises. Second, by integrating these factors into the analysis, the study offers novel insights into the broader policy discourse on human resource development - specifically, whether it serves as a vehicle for mutual supply chain enhancement or constitutes an inefficiency trap. While HR training, in principle, mirrors developmental inflows from other organisational investments by providing capabilities for growth, its operational implications and effects on supply chain sustainability depend on how effectively enterprises allocate and manage these resources - a process inherently shaped by organisational culture and technological adaptability.

The remainder of this paper is organised as follows. Section 1 reviews the literature on HR training, SCE, and mediating factors. Section 2 introduces the theoretical framework and hypotheses. Section 3 describes the data and empirical methodology. Section 4 presents the estimated effects of HR training on SCE through mediators. Finally, Section 5 concludes the study with a summary and policy recommendations.

1. LITERATURE REVIEW

1.1. HR TRAINING AND SUPPLY CHAIN EFFICIENCY

Human resource (HR) training equips employees with critical skills, knowledge, and competencies to streamline supply chain processes, directly boosting efficiency through reduced errors, enhanced coordination, and promoted innovation. Mechanistically, training in lean and agile methodologies enables workers to pinpoint inefficiencies, optimise workflows, and minimise waste and delays (Christopher, 2000; Sanders, 2016). Technology-oriented programmes, such as those on Enterprise Resource Planning (ERP), Radio Frequency Identification (RFID), and blockchain, further improve data accuracy, traceability, and decision-making (Queiroz et al., 2019). Similarly, Total Quality Management

(TQM) and Kaizen initiatives cultivate continuous improvement and defect minimisation (Deming, 1986; Imai, 1986).

Based on empirical evidence, targeted HR interventions enhance learning and performance, yielding cost savings and responsiveness gains (Haq et al., 2021). Green HR training integrates sustainable practices and environmental collaboration, amplifying firm outcomes (Agyabeng-Mensah et al., 2020). Systematic reviews highlight HR's role in bridging skill gaps to achieve operational excellence (Hohenstein et al., 2015), while recent studies on high-involvement HRM show that it fosters resilience and adaptability through employee participation and versatility (Gu et al., 2023; Kumar et al., 2020). Organisations that merge HR training with digital transformation achieve superior resilience and efficiency (Hasan et al., 2022; Fu et al., 2023). These mechanisms - skill augmentation, process refinement, and adaptive innovation - solidify the direct, positive impact of HR training on supply chain efficiency.

1.2. TECHNOLOGICAL ADAPTABILITY BETWEEN HR TRAINING AND SUPPLY CHAIN EFFICIENCY

Technological adaptability (TA) mediates the relationship between HR training and supply chain efficiency (SCE) by enabling employees to integrate emerging technologies, such as ERP systems and AI, into operations. Mechanistically, HR training builds digital literacy, reducing resistance to change and facilitating seamless adoption, thereby enhancing data accuracy, forecasting, and resilience (Cascio & Montealegre, 2016; Ivanov et al., 2019). Studies show that technology-enabled capabilities, nurtured through training, mediate performance gains in dynamic environments, like healthcare, where integration and resilience lead to sustainable efficiency (Junaid et al., 2023). ERP implementation, often supported by knowledge-focused training, similarly mediates organisational performance by bridging skill development to operational outcomes (Karim et al., 2023). This pathway - training fostering adaptability, which optimises technological utilisation - amplifies SCE in volatile markets (Teece et al., 1997).

1.3. ORGANISATIONAL CULTURE BETWEEN HR TRAINING AND SUPPLY CHAIN EFFICIENCY

Organisational culture (OC) mediates the impact of HR training on supply chain efficiency by embed-

ding shared values and norms that align behaviours with operational goals. Mechanistically, training reinforces collaborative and innovative cultures, reducing silos and promoting continuous improvement, thereby enhancing coordination and reducing costs (Schein, 2010; Denison & Mishra, 1995). Evidence from the banking sector indicates that HR practices shape culture, mediating employee performance and efficiency (Khaskheli et al., 2025). Innovation-driven cultures, cultivated via training, further mediate organisational outcomes, linking cultural alignment to performance (Imran et al., 2022). Learning-oriented cultures, supported by knowledge management training, serially mediate intelligence and efficiency gains (Meher et al., 2023). This intermediary role - the moulding culture of training, which sustains efficient practices - strengthens SCE in competitive settings (Cameron & Quinn, 2017).

The following hypotheses were proposed to address this gap:

H1: HR training positively influences organisational culture.

H2: HR training positively influences technological adaptability.

H3: HR training positively influences supply chain efficiency.

H4: Organisational culture positively influences supply chain efficiency.

H5: Technological adaptability positively influences supply chain efficiency.

2. RESEARCH METHODS

2.1. CONCEPTUAL FRAMEWORK AND EMPIRICAL MODEL

Human resource (HR) training serves as a foundational mechanism for enhancing organisational performance by developing employee competencies, aligning them with strategic goals, and promoting adaptive behaviours (Armstrong & Taylor, 2014). Theoretically grounded in social learning theory (Bandura, 1977), it facilitates knowledge acquisition through observation and practice, while andragogy (Knowles et al., 2005) emphasises self-directed learning for practical application. The Kirkpatrick Model (Kirkpatrick & Kirkpatrick, 2006) provides a mechanistic evaluation of training outcomes, linking individual reactions and behaviours to organisational results (Fig. 1).

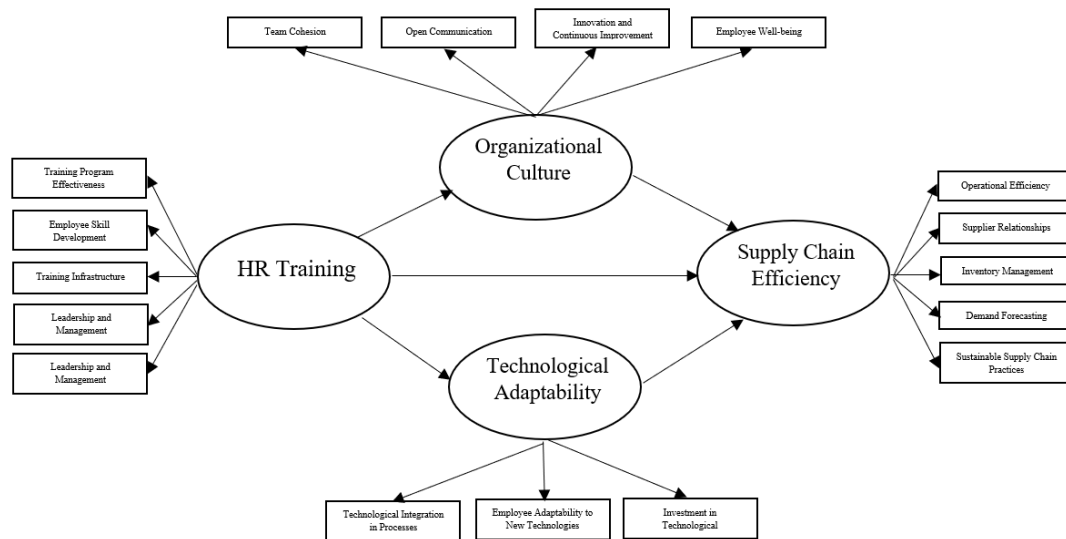


Fig. 1. Conceptual framework

Supply chain efficiency (SCE) operates through optimisation mechanisms that reduce inefficiencies and enhance value creation, drawing from lean principles (Womack et al., 1990) to eliminate wastes such as overproduction and defects. This theory posits that coordinated processes minimise costs and delays, supported by digital tools for real-time coordination (Christopher, 2016; Emon et al., 2024), ultimately fostering responsiveness and sustainability.

Building on the literature review, HR training directly boosts SCE by equipping employees with skills for process refinement and innovation, while indirectly amplifying it via organisational culture and technological adaptability. As per Schein's (2010) model, organisational culture acts as a mediating mechanism by embedding shared norms that reinforce the effects of training, enabling collaboration and resilience (Zen et al., 2023). Technological adaptability, rooted in dynamic capabilities theory (Teece et al., 1997), mediates by translating trained skills into effective technology integration, improving decision-making and agility (Bowersox et al., 2020; Fu et al., 2023).

Thus, the conceptual framework hypothesises that HR training positively influences organisational culture and technological adaptability, which in turn drive SCE. This integrated model underscores the mechanistic interplay of human capital development within cultural and technological contexts for sustainable supply chain outcomes (Gowen & Tallon, 2003; Huo et al., 2021).

$$SCE = \beta_1 HRT + \beta_2 OC + \beta_3 TA + \epsilon.$$

2.2. DATA AND SAMPLE

This study used a mixed-methods approach, integrating quantitative survey data with qualitative interviews to provide a comprehensive analysis of the impact of HR training on SCE. Quantitative data were collected over two months via online questionnaires. Participants were informed of the study's purpose, the voluntary nature of their participation, and confidentiality. Next, qualitative interviews were scheduled to build on the quantitative findings, ensuring method integration. Preliminary quantitative analysis used SPSS 26 for descriptives and normality checks (skewness and kurtosis within ± 2). CFA and SEM were conducted in AMOS 26 to assess measurement and structural models. Qualitative data were transcribed, coded, and triangulated with quantitative results to enhance validity and depth.

For the quantitative component, the study subjects were employees of supply chain-related enterprises in Guiyang, covering manufacturing, logistics, and service industries. The target population was approximately 1,600 employees from ten enterprises. The sample size was estimated using G*Power software, requiring at least 300 participants to achieve a moderate effect size and a statistical power of 0.95. Stratified random sampling was used to ensure representativeness across industries (e.g., 40 % manufacturing, 30 % logistics, and 30 % services) and organisational levels (operations, management, and supervisory). Questionnaires were distributed online to 400 potential respondents, yielding 303 valid responses (a response rate of 75.75 %). The sample structure in Tab. 1.

Tab 1. Participant demographics

CATEGORY	DESCRIPTION	PERCENTAGE
Gender	Female	58.2
	Male	39.2
	Undisclosed	2.6
Age	Under 30	2.1
	Between 31 and 35	14.6
	Between 36 and 40	55.2
	Over 40	28.1
Education	Bachelor's degree	3.8
	Master's degree	84.4
	Doctoral degree	11.8
Monthly Income	Below RMB 6,000	1.6
	6,001- 8,000	10.4
	8,001-10,000	40.0
	Over RMB 10,001	48.0
Occupation	Administrative management	47.3
	Operations	35.0
	Financial accounting	9.3
	Management	4.7
	Self-employment	2.0
	Supervisory roles	1.7

2.3. VARIABLES AND MEASUREMENT

Variables for the quantitative component were measured using a structured questionnaire divided into Part I (demographics) and Part II (constructs), with responses rated on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Items were adapted from validated scales:

HR training (HRT): 4 items focusing on development, effectiveness, and support (Bandura, 1977; Armstrong & Taylor, 2014).

Organisational culture (OC): 4 items on teamwork, communication, innovation, and engagement (Schein, 2010; Cameron & Quinn, 2011).

Technological adaptability (TA): 3 items on integration, literacy, and readiness (Teece et al., 1997; Garavan, 2007).

Supply chain efficiency (SCE): 5 items on coordination, responsiveness, cost management, and sustainability (Christopher, 2016; Womack et al., 1990).

Content validity was ensured through the item-objective congruence (IOC) index (> 0.50) assessed by three experts (Rovinelli & Hambleton, 1977). A pilot test ($n = 30$) yielded Cronbach's $\alpha > 0.70$ for all constructs. Confirmatory factor analysis (CFA) confirmed factor loadings ranging from 0.62 to 0.89

($p < 0.001$, no loadings at 1.0); convergent validity (composite reliability [CR] > 0.70 , average variance extracted [AVE] > 0.50 ; Fornell & Larcker, 1981); and discriminant validity (square root of AVE $>$ inter-construct correlations, heterotrait-monotrait [HTMT] ratio < 0.85 ; Henseler et al., 2015). Two correlated error terms (between OC innovation and TA readiness) were included, justified theoretically by overlapping constructs (e.g., innovation often requires technological readiness), and kept minimal to avoid artificially inflating fit indices (Kline, 2015). Detailed correlation analyses for observed and latent variables are provided in Appendix A, as they support preliminary checks but do not directly advance the main SEM argument.

3. RESEARCH RESULTS

Preliminary data analysis was performed using SPSS version 26, followed by confirmatory factor analysis (CFA) and structural equation modelling (SEM) using AMOS version 26. The specific steps were as follows: descriptive statistics were used to summarise the basic characteristics of the respondents (see Section 3.2 for sample details). Skewness and kurtosis values were within ± 2 , validating the normality of the data. Reliability was assessed using Cronbach's α coefficient and CR values. CFA was performed to evaluate the measurement model, including factor loadings and model fit indices.

3.1. MEASUREMENT MODEL

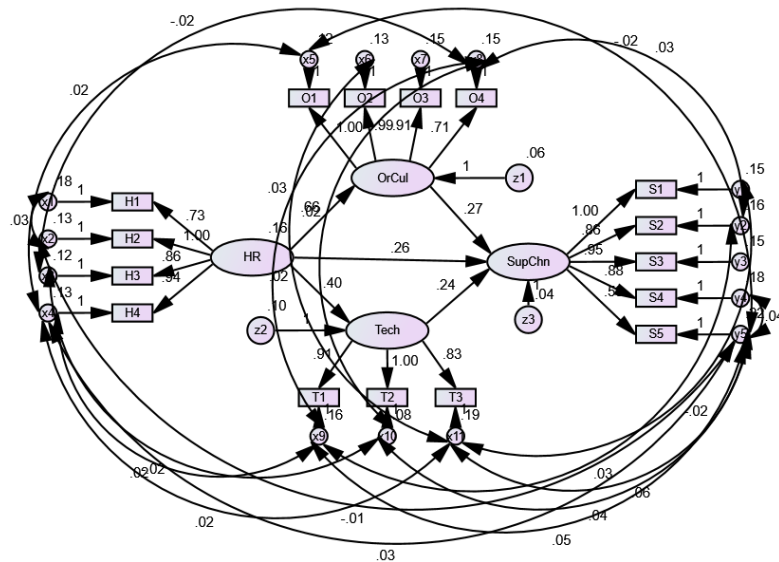
The measurement model was assessed through CFA to evaluate its quality, including convergent and discriminant validity (Fornell & Larcker, 1981; Henseler et al., 2015). Factor loadings for all items ranged from 0.62 to 0.89 ($p < 0.001$), with no loadings at 1.0, indicating no issues with model specification or data processing. Convergent validity was confirmed by composite reliability (CR) values exceeding 0.70 for all constructs and average variance extracted (AVE) values above 0.50. Discriminant validity was established as the square root of AVE for each construct was greater than its correlations with other constructs, and the heterotrait-monotrait (HTMT) ratio was below 0.85. The model included two correlated error terms (between organisational culture innovation and technological adaptability readiness), justified theoretically by conceptual overlap (e.g., innovation often requires technological readiness;

Kline, 2015). These were kept to a minimum to prevent artificial inflation of fit indices. The measurement model showed good fit ($\chi^2/df = 1.30$, CFI = 0.98, RMSEA = 0.03), providing a solid foundation for the structural model.

3.2. STRUCTURAL MODEL

The structural model, presented in Fig. 2 with standardised coefficients, examines the direct and indirect effects of HR training on supply chain efficiency through organisational culture and technologi-

cal adaptability. As shown in Table 2, HR training exerts a significant positive total effect on organisational culture ($\beta = 0.664$, $p < 0.01$) and technological adaptability ($\beta = 0.399$, $p < 0.01$). Its total effect on supply chain efficiency is 0.534 ($p < 0.05$), comprising a direct effect of 0.262 and an indirect effect of 0.272 through the mediators. Organisational culture has a direct effect on supply chain efficiency of 0.268 ($p < 0.05$), while technological adaptability has a direct effect of 0.236 ($p < 0.05$). Mediation analysis confirms partial mediation: HR training influences supply chain efficiency indirectly through organisational culture



Chi-square = 103.573, df = 80, Chi-square/df = 1.295, p = .039, GFI = .960, AGFI = .933, CFI = .984, TLI = .976, RMSEA = .031, RMR = .013, NFI = .934

Fig. 2. Structural equation modelling of the impact of human resource training on supply chain efficiency in Guiyang’s enterprises

Tab. 2. Model summary

DEPENDENT VARIABLES	ORGANISATIONAL CULTURE			TECHNOLOGICAL ADAPTABILITY			SUPPLY CHAIN EFFICIENCY		
	TE	DE	IE	TE	DE	IE	TE	DE	IE
Independent variables									
HR training	0.664**	0.664**	-	0.399**	0.399**	-	0.534*	0.262*	0.272*
Organisational culture	-	-	-	-	-	-	0.268*	0.268*	-
Technological adaptability	-	-	-	-	-	-	0.268*	0.268*	-
R-square		0.528			0.203			0.567	

Note: p < 0.05 (*), p < 0.01 (**)

Model fit statistics:

$\chi^2 = 103.573$, $df = 80$, $\chi^2/df = 1.295$, $p = 0.039$, $GFI = 0.960$, $CFI = 0.984$, $TLI = 0.976$, $NFI = 0.934$, $RMSEA = 0.031$, $RMR = 0.013$.

(indirect effect = 0.178, $p < 0.05$) and technological adaptability (indirect effect = 0.094, $p < 0.05$). The model's explanatory power is robust, with R^2 values of 0.528 for organisational culture, 0.203 for technological adaptability, and 0.567 for supply chain efficiency. Model fit statistics indicate a well-specified model ($\chi^2 = 103.573$, $df = 80$, $\chi^2/df = 1.295$, $p = 0.039$, GFI = 0.960, CFI = 0.984, TLI = 0.976, NFI = 0.934, RMSEA = 0.031, RMR = 0.013). Detailed correlation analyses for observed and latent variables are provided in Appendix A, as they support preliminary checks but do not directly advance the main SEM argument.

3.3. QUALITATIVE RESULTS

Qualitative data from 15 semi-structured interviews were analysed using thematic analysis (Braun & Clarke, 2006) and coded in NVivo software. The analytic framework was grounded in the conceptual model, linking themes directly to the research questions and constructs (HR training, organisational culture, technological adaptability, and supply chain efficiency). The coding procedure involved open coding to identify initial patterns, axial coding to establish relationships, and selective coding to refine core themes. Three key themes emerged: (1) skill enhancement through training: respondents emphasised the role of training in boosting efficiency, with one noting that "Training helped us reduce inventory errors by 20 %" (Manager A), linking the result to HR training and supply chain efficiency; (2) cultural alignment: participants highlighted improved collaboration post-training, e.g., "Our team culture improved post-training, leading to better supplier coordination" (Supervisor B), connecting the result to organisational culture as a mediator; (3) technological integration: adaptability was seen as critical; one participant commented that "Digital tools are useless without trained staff" (Manager C), tying training to technological adaptability's role in enhancing supply chain outcomes. These themes corroborate the quantitative findings, illustrate practical mechanisms, and reinforce the model's validity. For space constraints, a coding tree, exemplar quotes, and an analysis outline are provided in Appendix B.

CONCLUSIONS

This study employed a mixed-methods design, utilising structural equation modelling (SEM) for quantitative analysis and thematic analysis for quali-

tative insights, to investigate the impact of human resource (HR) training on supply chain efficiency (SCE) in enterprises located in Guiyang, China. The quantitative results confirmed that HR training exerts direct and indirect positive effects on SCE through the mediating roles of organisational culture and technological adaptability. Specifically, HR training significantly enhances organisational culture ($\beta = 0.664$, $p < 0.01$) and technological adaptability ($\beta = 0.399$, $p < 0.01$), thereby contributing to improved SCE (direct effect: $\beta = 0.262$, $p < 0.05$; indirect effect: $\beta = 0.272$, $p < 0.05$). The model's explanatory power is robust, with R^2 values of 0.528 for organisational culture, 0.203 for technological adaptability, and 0.567 for SCE, underscoring the pivotal role of employee development and technological readiness in driving operational excellence within supply chains. Qualitative findings from semi-structured interviews with 15 managers and supervisors confirmed these outcomes, revealing key themes such as skill enhancement, cultural alignment, and technological integration that illustrate the practical mechanisms underlying these relationships.

The findings advance the literature by integrating HR training, organisational culture, and technological adaptability into a unified empirical model of supply chain performance, addressing gaps in prior research that often examined these variables separately (Huo et al., 2021; Fu et al., 2023). This study contributes novel insights into socio-technical systems theory (Trist & Bamforth, 1951), demonstrating how human capital development interacts with cultural and adaptive factors to enhance efficiency and competitiveness in transitional economies.

From a managerial perspective, the results suggest that enterprises in Guiyang and similar regions should prioritise strategic investments in HR training programmes aligned with organisational values and technological priorities to foster collaboration, innovation, and resilience. Policymakers could support this through public-private partnerships, tax incentives, and industry-wide initiatives to promote workforce upskilling and regional supply chain sustainability.

Although this study offers robust evidence, several limitations warrant acknowledgement. The cross-sectional quantitative design limits causal inferences, while the qualitative sample of 15 interviews may constrain broader perspectives. Data collection relied on self-reported surveys, potentially introducing common method bias, and online distribution may have excluded participants who were less

digitally accessible. Analytically, the SEM assumptions of normality and linearity were met, but could be sensitive in expanded datasets; the two correlated error terms, though justified, highlight possible conceptual overlaps. These constraints inform future research, including longitudinal designs to establish causality, larger and more diverse samples across provinces, and incorporation of additional variables, such as leadership or economic policies. Further qualitative expansions through case studies could validate themes and explore human-centric supply chain dynamics in greater depth.

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