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Influencing factors and mechanisms of collaborative governance within the integration of industry and education in Yunnan's higher vocational education

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Abstract
This study aimed to explore the influencing factors and mechanisms of collaborative governance in the integration of industry and education in Yunnan's higher vocational education. The study employed quantitative research methods to collect data from 496 valid respondents across four stakeholder groups: government departments, enterprises, vocational colleges, and industry associations. Descriptive results showed that the mean subjective evaluations from all stakeholders are at a medium-to-high level (3.81–4.10). However, information search and negotiation costs (M=3.85) and property rights delineation costs (M=3.86) remain significant obstacles. The correlation coefficients between the indicated transaction cost factors (information search and negotiation costs, and property rights definition costs) and university-enterprise collaborative behavior were 0.411 and 0.434, respectively (although the pairwise correlation was positive, the net effect showed a significant negative suppression in the path model). Meanwhile, the r-values for regional social capital, cultural identity, local government coordination and participation, and industry association participation were 0.311, 0.501, 0.544, and 0.581, respectively, all showing significant positive associations and good discriminant validity. VensimPLE software found that the 2018-2035 simulation revealed obvious stage heterogeneity: The facilitating effect of local government coordination and participation has steadily increased from 0.04% in 2018 to 3.52% in 2035 (the strongest core driving force, which can play an equivalent substitute role when industry associations are weak). The regional social capital effect has increased to 2.36% (exceeding the 1.77% of industry associations). The mitigating effect of reducing information search and negotiation costs is 1.11% (a persistent obstacle throughout the entire cycle). The effect of reducing property rights delineation costs peaked in 2023 (2.56%) and then stabilized. Cultural identity maintains a stable contribution of 0.55%–0.65%. This study proposes mechanisms such as building information platforms and clarifying property rights to reduce transaction costs, offering practical insights for enhancing collaborative governance in Yunnan and beyond.

Keywords:

Collaborative Governance; Industry-Education Integrati
Vocational Education; Yunnan Province; Transaction Costs

A. INTRODUCTION

Tourism, advanced manufacturing and characteristic agriculture constitute important pillars of Yunnan's regional economy. Meanwhile, the mismatch between skilled-talent supply and industrial demand remains prominent in local higher vocational education. Nationwide, higher vocational education is confronted with structural imbalances between theoretical teaching and practical training. Statistical evidence demonstrates the co-existence of graduate unemployment and skilled-labour shortages (MOE, 2024; MOHRSS, 2023). Even though central and provincial authorities have rolled out serial policies promoting industry-education integration, practical cooperation still falls into the stalemate of "colleges active, enterprises lukewarm".

International experience represented by Germany's dual vocational-training system proves that deep multi-party participation is essential for linking education chains with industrial chains (Bundesinstitut für Berufsbildung, 2024). Nevertheless, direct transplantation of foreign models encounters institutional obstacles in China: industry associations lack statutory governance authority, private-sector employee turnover remains high, and social preference for academic credentials weakens students' willingness for on-site skill training. Existing domestic studies mostly describe cooperation patterns, while insufficient attention has been paid to micro-level transaction-cost constraints and stage-differentiated action logics of multiple stakeholders. Many papers adopt a simple "problem-countermeasure" paradigm without unpacking causal mechanisms behind collective-action dilemmas.

This study took public higher-vocational colleges across Yunnan Province as analytical units. It follows the logical chain of "demand identification → collaborative planning → implementation" to unpack interactions among government, colleges, enterprises and industry associations. The findings contribute meso-level organisational solutions for stimulating enterprise-driven high-cost skill cooperation in Yunnan and other similar regions. Practically, this study yields a collaborative-governance roadmap, power-boundary list, and regional operation manual, facilitating closed-loop operation of "industrial demand → talent cultivation → technology iteration" and supporting coordinated regional economic development.

Research Questions

RQ1:What is the current situation of multi-stakeholder school-enterprise collaborative governance in Yunnan's higher vocational education, and what transaction-cost barriers exist in the actual industry-education integration practice?

RQ2: What are the correlation relationships among transaction-cost factors, regional social capital, cultural identification, multi-subject participation, and school-enterprise collaborative-governance behaviours?

RQ3: What are the predictive effects of each influencing factor on school-enterprise collaborative-governance behaviour?

Research Hypotheses

H1: Multi-stakeholders' evaluations of school-enterprise collaborative governance in Yunnan's higher vocational education are at a moderate level, while transaction-cost barriers remain prominent.

H2: Transaction-cost factors are significantly negatively correlated with school-enterprise collaborative-governance behaviors; regional social capital, cultural identification, and multi-subject participation show significant positive correlations with collaborative-governance behaviors.

H3:Influencing factors exert predictive effects on school-enterprise collaborative-governance behavior with time-variant magnitudes, and local-government coordination & participation produces the strongest promoting effect.

Research Objectives

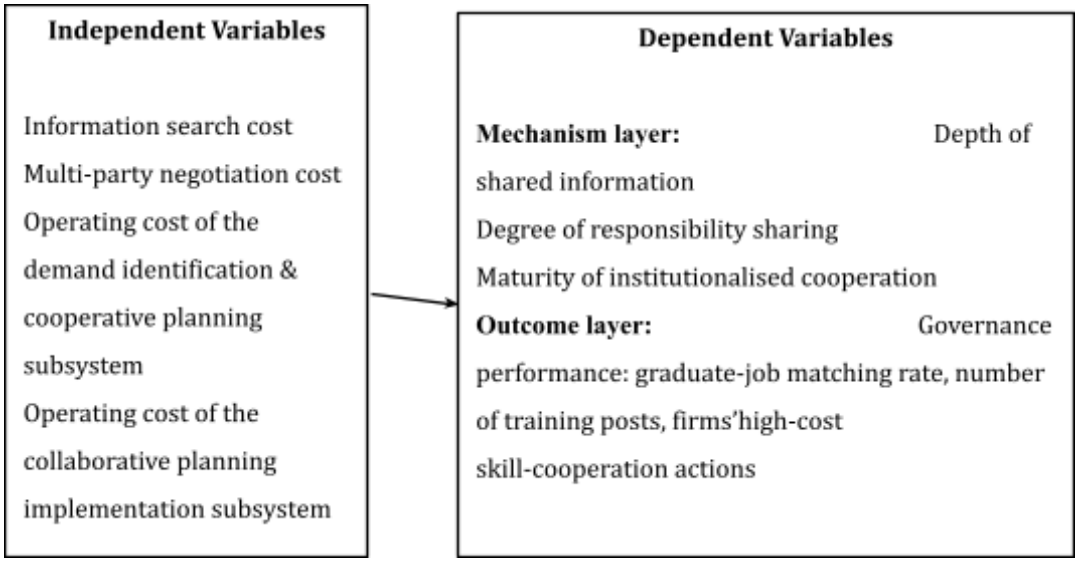
To investigate the current situation of multi-stakeholder school-enterprise collaborative governance in Yunnan higher vocational education and identify existing transaction-cost barriers.

To examine the correlation relationships among transaction-cost factors, regional social capital, cultural identification, multi-subject participation, and school-enterprise collaborative-governance behaviours.

To verify the predictive effects of each influencing factor on school-enterprise collaborative-governance behaviour, test time-variant heterogeneity of effect magnitudes, and identify the core driving factor.

Research Framework

The Influence of Collaborative Governance Factors and Mechanisms (IV) on Industry-Education Integration (DV): A Study in Yunnan's Higher Vocational Education Context.



Figures 1.1Conceptual Framework

LITERATURE REVIEW

Related Theories

Existing domestic and international studies on higher vocational education industry-education integration and collaborative governance have formed a relatively systematic research system covering multi-actor participation, integration models, and governance mechanisms. In terms of multi-actor participation in higher vocational education, academic circles have broken through the traditional binary "government-school" governance structure and reached a consensus that enterprises, industry associations, and other social forces need to move from peripheral participation to core participation in vocational education. Zhou (2019) deconstructed higher vocational education into the four-dimensional logic of industry-education integration, school-enterprise cooperation, engineering-practice integration, and knowledge-action integration, advocating for building a multi-agent collaborative education network involving governments, industries, enterprises, and social organizations. Nevertheless, Ma and Song (2019) pointed out the practical dilemmas of subject dislocation and insufficient enterprise subjectivity in such collaborative systems, emphasizing the necessity of constructing a multi-party linkage operation mechanism. He (2020) proposed a dual-track operation framework of a planned track and a market track for vocational education, and Hu et al. (2019) further argued that the industry-education integration system has transformed from government unipolar governance to multi-polar co-governance, featuring enterprise participation in core decision-making, diversified institutional forms, and multi-source fundraising mechanisms. The academic community has formed two

conflicting theoretical paradigms: the government-led theory that stresses public attribute guarantee and policy regulation to avoid market failure, and the market-driven theory that advocates decentralizing educational governance rights to stimulate industrial vitality. In terms of international research, Li (2019) highlighted that the core advantage of German vocational education lies in enterprises' full-process embedded participation rather than passive cooperation. Christian (2011) identified multiple actors in industry-university-research alliances and confirmed the dominant niche of enterprises in vocational education collaborative ecology. In addition, early domestic studies by He (2014) emphasized the market adaptation of vocational education reform, while Lv et al. (2021) upgraded enterprises' role from passive participants to core leaders, and Bao (2016) proposed institutionalized solutions for deep integration such as joint entity construction and multi-source financing.

Related Studies

In terms of industry-education integration practice of higher vocational education, domestic scholars have summarized abundant practical cooperation forms and operational mechanisms. Lan (2013) concluded five typical industry-embedded integration modes through field investigation, covering park-oriented training, joint technology research centers, enterprise-run secondary colleges, teacher team co-construction, and enterprise student studios. Wang et al. (2015) constructed a three-dimensional cooperation mechanism of contract-based projects to realize the docking of enterprise R&D demands and vocational talent training. Pan (2021) supplemented diversified organizational forms such as park embedding, group schooling, and modern apprenticeships with empirical evidence. Jin (2015) further refined specific cooperation carriers, including internship bases, joint laboratories, and teaching funds. From the perspective of knowledge production theory, Hu (2019) pointed out that school-enterprise cooperation has evolved from resource dependence to value co-creation, relying on four core dimensions of demand matching, organizational adaptation, resource integration, and cultural integration. Liu et al. (2015) established a multi-dimensional spectrum framework covering R&D cooperation, resource sharing, project traction, and talent flow. Internationally, Lee (1996) clarified the differentiated cooperation motivations of universities and enterprises. Gaskill (2003) proposed that inter-organizational trust and commitment are key to breaking cooperation barriers. Based on empirical data from transnational industry-university-research institutions, Hemmert (2014) verified the interactive relationship between innovation performance, trust, and sustained cooperation. Bstieler et al. (2017) and Barnes (2002) further supplemented the moderating effect of relationship maturity and core elements of successful cross-border cooperation. Karmakar (2014) summarized a three-stage dynamic cooperation model of demand docking, policy catalysis, and goal consensus. In the field of collaborative governance, existing research adopts transaction cost theory, property rights theory, and principal-agent theory to analyze vocational education governance dilemmas. Xiao (2016) attributed enterprises' passive participation to high cooperative costs and unclear strategic matching. Wang (2018) explained enterprises' internal and external training selection logic based on marginal cost and asset specificity. At the micro institutional level, Shen (2021) analyzed the dual constraints of external institutional environment and internal governance structure on multi-subject collaborative governance in mixed-ownership education. Zhang (2014) revealed the policy virtualization and formal cooperation dilemmas caused by hierarchical institutional logic and selective implementation. Foreign localized practice research by Fortwengel (2017) and Remington and Marques (2020 further confirmed that local governments can effectively break collective action dilemmas through platform construction, policy guarantee, and flexible institutional arrangement.

Summary

Despite the fruitful achievements of existing studies, there are still obvious research gaps to be addressed. First, most studies stay on static pattern induction and normative description, failing to reveal the micro "input-transformation-output" operation mechanism between multiple subjects (Hu et al., 2019; Liu et al., 2015). Second, domestic and foreign research perspectives are fragmented, lacking a systematic analytical framework that integrates macro institutions, meso

mechanisms, and micro behaviors (He, 2020; Bstieler et al., 2017). Third, existing studies pay insufficient attention to the core coordinating role of local governments, with inadequate theoretical refinement and empirical verification of their governance logic (Remington & Marques, 2020; Fortwengel, 2017).

METHOD

RESEARCH DESIGN

This study adopted a quantitative research method to collect data. Macro statistical indicators were extracted from the Yunnan Statistical Yearbook (2020-2025). Micro-level perceptual data were collected via questionnaires targeting four stakeholder groups: government-department officials, enterprise managers, higher-vocational-college teachers, and industry-organisation staff. After data collection, reliability and validity testing, descriptive-inferential statistics and system-dynamics simulation were sequentially performed.

Population and Samples

The research population covered four groups across Yunnan: prefecture-level education-bureau officers, human-resources-and-social-security-department staff, senior management or HR personnel from enterprises with over 50 employees, and full-time teachers of public higher-vocational colleges. Stratified random sampling was adopted considering geographical zoning, industrial sectors, and institutional types. Eligible respondents must have direct work experience related to industry-education integration practice. Based on a 95% confidence level and 5% margin of error, the required sample size was 500. A total of 500 questionnaires were distributed, and 496 valid responses were obtained, yielding an effective response rate of 98.0 %.

Data Collection

Method: Anonymous online instrument selected given the spatial dispersion of targets; rapid electronic reach; anonymity mitigating social-desirability effects; and quantitative analytical requirements.

Instrument: Seven-dimensional, 20-item measure constructed on Wenjuan-x, combining Likert scales with categorical items. Pre-test (n=60) October 2025.

Procedure: (1) November 2025: instrument lock and institutional review; (2) access agreements with provincial departments, vocational networks, and sampled colleges; (3) 1 December 2025: multi-channel invitation dispatch (email, WeChat, SMS) with integrated consent; (4) 28-day collection with weekly prompts; (5) algorithmic screening for speed (<3 min) and coherence.

Schedule: Data gathering: 1–30 December 2025; processing: complete by 5 January 2026.

Ethical protocols: Opt-in participation, revocable without penalty; anonymised responses; scholarly use exclusively; secure storage with a three-year destruction timeline.

Validity and Reliability

Content validity of the questionnaire was assessed using the Item-Objective Congruence (IOC) index. Three domain experts, including a vocational education administrator, an enterprise human resource manager, and a research scholar, independently rated the alignment between each measurement item and its corresponding research dimension on a scale of $+1, 0, -1$. All items yielded IOC indices ranging from 0.67 to 1.00, with a mean value of 0.89, exceeding the critical threshold of 0.50, which confirmed satisfactory content validity. Minor wording revisions were implemented for two items according to expert feedback.

Internal consistency reliability was tested by calculating Cronbach's α coefficient via SPSS 22.0. The overall Cronbach's α of the formal questionnaire reached 0.925, higher than the benchmark value of 0.70, indicating good internal reliability for the whole scale.

Confirmatory factor analysis (CFA) implemented in AMOS 23.0 was used to test construct validity. Model fit indices were acceptable: $\chi^2/df = 1.325$, GFI = 0.916, CFI = 0.969, NFI = 0.903,

RMSEA = 0.031. Discriminant validity was verified, as the square root of the Average Variance Extracted (AVE) for each latent variable was greater than the correlation coefficients between constructs. These outcomes demonstrated adequate construct validity for the measurement instrument.

Data Analysis

SPSS 22.0 and AMOS 23.0 software were used for statistical analysis—descriptive statistics produced mean values, standard deviations, and frequency distributions. Correlation analysis was used. Confirmatory factor analysis tested questionnaire construct validity; Vensim PLE software was applied for system-dynamics modelling. After conceptual model construction, intuitive validation, operational validation, and Monte-Carlo-based sensitivity testing were completed to ensure model robustness. The simulation period spanned 2018-2035 with a simulation step of 0.0625

RESULTS

Descriptive Statistics

Table 1 Basic Information of Effective Samples (N=496)

Name	Category	Frequency	Percentage (%)
Gender	Male	224	45.16
	Female	272	54.84
Name	**Category**	**Frequency**	**Percentage (%)**
Age	Under 30 years old	266	53.62
	31～40 years old	153	30.85
	41～50 years old	64	12.9
	Over 50 years old	18	3.6
Academic qualification	Associate degree or below	29	5.8
	Undergraduate	245	49.39
	Postgraduate	222	44.76
Nature of work	School	270	54.44
	Enterprise	160	32.26
	Government department	66	13.3
Years of Work Experience	<1 year	60	12.1
	1～5 years	110	22.18
	5～10 years	281	56.65
	>10 years	45	9.1
Total		496	100%

Table 1 shows that the proportion of males and females in the sample is 45.16% and 54.84%, respectively, with the latter slightly dominant. From the perspective of age structure, the respondents are mainly concentrated in two groups: the group aged 30 and below accounts for 53.62%, and the group aged 31-40 accounts for 30.85%, with a cumulative total of over 80%. This age group is the core participant and practical subject of the current integration of industry and education in higher vocational education, and their views can fully reflect the cognition and attitude of various stakeholders towards collaborative governance in the new era.

In terms of educational level, the respondents are mainly undergraduate (49.39%) and graduate (44.76%), with a total of over 94%, which is consistent with the general qualification status of practitioners in the field of higher vocational education. From the perspective of unit nature, the sample covers three core entities: schools account for 54.44%, enterprises account for 32.26%, and government departments account for 13.30%.

In terms of years of work experience, respondents with 5-10 years of work experience have the highest proportion, reaching 56.65%; 22.18% of the participants have 1-5 years of experience. This indicates that the vast majority of respondents have been deeply involved in the field of higher vocational education for a long time and have a deep understanding and high

recognition of the integration of industry and education. The information provided can objectively present the reality of collaborative governance.

H1:Multi-stakeholders' evaluations of school-enterprise collaborative governance in Yunnan's higher vocational education are at a moderate level, while transaction-cost barriers remain prominent.

Table 2. Recognition Assessment of Collaborative Governance Behaviors Among Different Higher Vocational Education Actors

Content	Indicator	Mean	S.D.	Interpretation
Information Search & Bargaining Costs	Cost of Information Search and Partner Selection	3.82	0.60	High
	Cost of negotiation for school enterprise cooperation	3.85	0.60	High
	Cost of negotiating educational and professional standards	3.81	0.60	High
Property-Rights Delineation Costs	Determination of non-human capital property rights	3.85	0.70	High
	Determination of Human Capital Property Rights	3.86	0.60	High
Regional Social Capital	History of school enterprise cooperation	3.92	0.80	High
	Elite Network Relationships	4.01	0.70	High
	Trustworthy commitment	3.95	0.60	High
Cultural Identification	Cultural identity of skilled talents	4.02	0.60	High
	Compatibility of school enterprise culture	3.94	0.70	High
Local-Government Coordination & Participation	Incentive policies for local integration of industry and education	4.02	0.70	High
	Construction of cooperation platform	4.05	0.60	High
	Establishment of Standards for Training Skilled Talents	3.96	0.80	High
Industry-Association Participation	Participate in the governance of higher vocational education	4.05	0.90	High
	Manage industry affairs	4.01	0.60	High
School–Enterprise Collaborative Governance Behaviors	Sharing Information	4.04	0.60	High
	Shared Responsibility	3.93	0.70	High
	Jointly promote the institutionalization of school enterprise cooperation	4.10	0.90	High

Table 2 shows that mean scores for all latent-variable indicators ranged from 3.81 to 4.10. Respondents gave relatively high evaluations for local-government coordination, industry-association participation and regional-social-capital conditions. Meanwhile, information-search-and-negotiation costs and property-rights-definition costs obtained high-level scores, which indicates transaction-cost barriers still widely exist in practical school-enterprise cooperation.

Inferential Statistics

H2: Transaction-cost factors are significantly negatively correlated with school-enterprise collaborative-governance behaviors; regional social capital, cultural identification, and multi-subject participation show significant positive correlations with collaborative-governance behaviours.

AMOS 23.0 software was used for confirmatory factor analysis, and a structural equation model was constructed to verify the validity of the questionnaire and extract factor loadings for each indicator. The obtained path coefficients provide a quantitative presentation of the relationships between indicators. These weight coefficients not only reveal the relative importance of each element to the overall system but also constitute a key component of the system dynamics model, used to define the functional relationships between variables.

The model fit indices obtained from the model run are presented in Table 4-3. The fit indices are as follows: $x^2/df = 1.416$, which is less than 5; GFI = 0.915, CFI = 0.958, NFI = 0.904, all greater than 0.9; RMSEA = 0.045, which is less than 0.08. Comparing these values to the fit criteria presented in the table, all results from the model analysis meet the relevant requirements, indicating that the model is suitable for analysis.

Table 3 Model Fit Indices

Index	x^2/df	GFI	PGFI	NFI	IFI	TLI	CFI	RMSEA
Criterion	<3	>0.9	>0.6	>0.9	>0.9	>0.9	>0.9	<0.10
Value	1.325	0.916	0.713	0.903	0.946	0.952	0.969	0.031

Table 4 Discriminant Validity: Pearson Correlations and Square Roots of AVE

	Information Search & Bargaining Costs	Property-Rights Delineation Costs	Regional Social Capital	Cultural Identification	Local-Government Coordination & Participation	Industry-Association Participation	School–Enterprise Collaborative-Governance Behaviors
Information Search & Bargaining Costs	0.564						
Property-Rights Delineation Costs	0.354**	0.623					
Regional Social Capital	0.443**	0.346**	0.713				
Cultural Identification	0.533**	0.483**	0.416**	0.676			
Local-Government Coordination & Participation	0.461**	0.492**	0.385**	0.649**	0.684		
Industry-Association Participation	0.384**	0.422**	0.339**	0.526**	0.525**	0.717	
School–Enterprise Collaborative-Governance Behaviors	0.411**	0.434**	0.311**	0.501**	0.544**	0.581**	0.652

*Note:** indicates $p < 0.01$. Bold values on the diagonal represent the square roots of the average variance extracted (AVE) for each latent variable. Off-diagonal values are Pearson correlation coefficients between latent variables.*

As shown in Table 4- 4, convergent validity is satisfactory. The AVE values of all seven latent variables exceed the threshold of 0.5, suggesting that the measurement items can effectively reflect their corresponding latent constructs, and the convergent validity of the scale is well qualified.

Significant positive correlations exist among all variables. All correlation coefficients are positive and significant at the 1% level. Specifically, the correlation between Cultural Identification and Local-Government Coordination & Participation is the strongest (0.649), while the correlation between Regional Social Capital and School–Enterprise Collaborative-Governance Behaviours is the

weakest (0.311). Institutional cost variables (i.e., information search & bargaining costs and property-rights delineation costs) are significantly and positively associated with cultural, governmental, industrial association, and school-enterprise governance factors.

H3: Influencing factors exert predictive effects on school-enterprise collaborative-governance behaviour with time-variant magnitudes, and local-government coordination and participation produces the strongest promoting effect.

Table 5 Comparative Table of Changes in Collaborative Governance Behavior Following the Evolution of Various Factors

Year	Initial Valu of School-Ent rprise Collaborati ve Governanc Behavior	Evolution of Information Search & Negotiation Costs		Evolution of Regional Social Capital		Evolution of Industry Association Participation		Evolution of Property Rights Delineation Costs		Evolution of Local Government Coordinatio n & Participatio n		Evolution of Cultural Identificati on	
		Post-evoluti on Effect Value	Reducti n (%)	Post-evo ution Effect Value	Reducti n (%)	Post-evolu ion Effect Value	Reducti n (%)	Post-evolu tion Effect	Reduc ion (%	Post-ev lution Effect Value	Reduc on (%	Post-evoluti on Effect Value	Reduct ion (%)
2018	5.3453	5.3253	0.40%	5.3642	0.03%	5.3564	0.06%	5.7344	0.30%	5.3135	0.04%	5.3735	0.60%
2023	7.6433	7.1434	1.03%	7.4224	2.49%	7.7453	1.335%	7.82350	1.13%	7.6352	2.56%	7.5731	0.55%
2028	11.5634	11.4324	1.04%	11.5235	2.76%	12.2346	1.62%	11.2346	1.21%	12.0964	3.12%	11.6427	0.65%
2035	18.7432	18.5346	1.11%	18.8235	2.36%	19.3415	1.77%	19.5136	1.25%	19.2322	3.52%	18.9632	0.62%

Based on the simulation data analysis in Table 4-5, a 20% improvement simulation was conducted on each influencing factor at four time points: 2018, 2023, 2028, and 2035. The study found significant differences in the degree of influence of various factors on school-enterprise collaborative governance behavior. Overall, the collaborative participation of local governments has the most significant effect on promoting cooperative behavior, with the increase rate continuing to climb from 0.04% in 2018 to 3.52% in 2035. The impact of industry association participation is also gradually increasing, rising from 0.06% in 2018 to 1.77% in 2035. Regional social capital has increased significantly from 0.03% in 2018 to 2.36% in 2035, indicating that as cooperation deepens and social trust accumulates, the role of regional social capital in promoting collaborative behavior is becoming increasingly prominent.

At the transaction cost level, the reduction in information search and negotiation costs has gradually expanded from 0.40% in 2018 to 1.11% in 2035, reflecting that these costs are the main obstacle to the sustainability of school enterprise cooperation, and their reduction has a positive impact on collaborative governance. The reduction in the cost of defining property rights will reach a peak of 2.56% in 2023 and then stabilize, indicating that clarifying property rights is a key issue in the mid-term of collaborative governance, and its impact will gradually stabilize with the improvement of the system. The increase in cultural identity maintained a stable range of 0.55% -0.65% in each period, demonstrating its sustained and stable support for collaborative behavior.

From the perspective of evolutionary trends, the increase in regional social capital by 2035 (2.36%) is approaching industry association participation (1.77%) and surpassing the decrease in information search and negotiation costs (1.11%). This highlights the important role of informal institutions and relational networks in long-term collaborative governance. In summary, the collaborative participation of local governments and industry associations constitutes a key formal mechanism for promoting school enterprise cooperation. The role of regional social capital as an informal mechanism continues to strengthen with the deepening of cooperation. At the same time, information search and negotiation costs have always been the main transaction obstacles faced by school enterprise cooperation.

Validation of the Higher Vocational Education Collaborative Governance System Model

Based on the empirical data collected in the previous analysis, this section constructs a system dynamics framework for collaborative governance of higher vocational education using Vensim PLE software. The following content outlines the validation procedures used to ensure model integrity. These results also support H3.

Intuitive Model Validation

Throughout the modeling process, this survey combines established academic findings with expert consultation. Using the results obtained from structural equation modeling analysis, the iterative refinement method is adopted to gradually debug and optimize the structural configuration and variable relationships to ensure that the framework fully reflects the actual system logic and operating mechanism.

Model Operational Validation

The effectiveness of this model needs to be validated through computational testing. This study observed whether there were any abnormalities in the model output by setting different simulation step sizes (1, 0.5, 0.25, 0.125, 0.0625). Checking key variables, including school-enterprise cooperation governance behavior, regional social capital, and local government coordination and participation, all indicators show a consistent trajectory, and there is no irregularity in the process of gradually shortening the step size to improve calculation accuracy. This pattern indicates that the framework has robust stability and effectiveness. The corresponding simulation results are shown in Figures 4-1, 4-2, and 4-3.

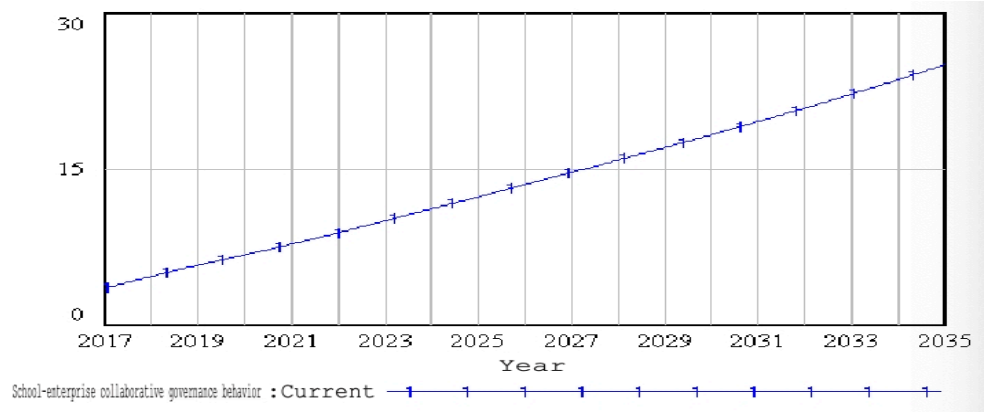


Figure 1: Simulation Results of School-Enterprise Collaborative Governance Behavior

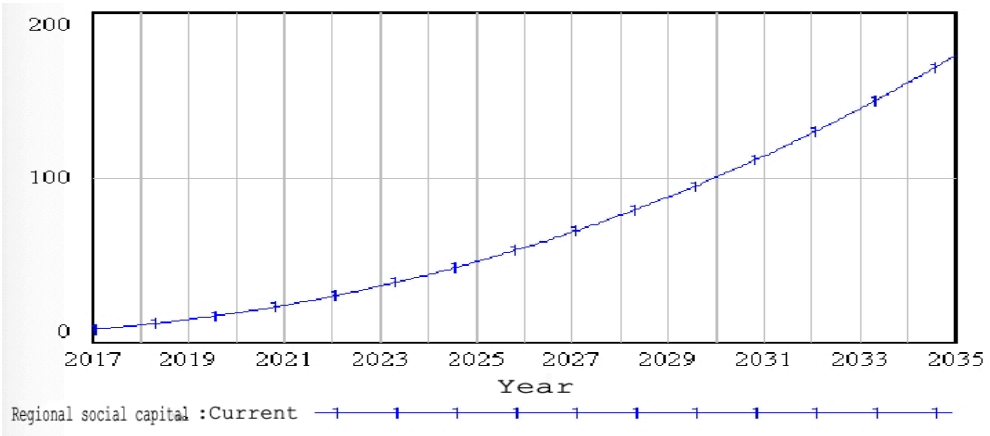


Figure 2: Simulation Results of Regional Social Capital

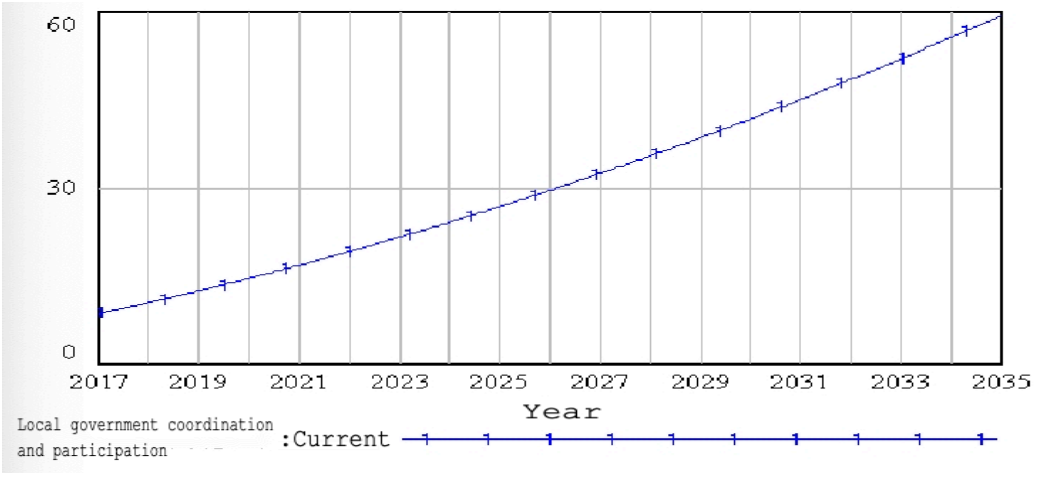


Figure 3: Simulation Results of Local Government Coordination Participation

Model Sensitivity Testing

Sensitivity analysis compares the output deviation of flow rate and flow potential variables by adjusting the values of core parameters or local architecture within the system, in order to identify the dominant factors that have a decisive impact on simulation results. This method helps to fully utilize these key elements in the process of system evolution, providing a basis for precise optimization of governance strategies and implementation modes. Sensitivity testing can generally be divided into two categories: architecture sensitivity analysis and parameter sensitivity analysis. Specifically, parameter sensitivity assessment involves making subtle adjustments to parameter values within a specific range and observing their impact on the dynamic behavior of the system. If subtle parameter disturbances cause significant fluctuations in the system output, it indicates that the variable is highly sensitive, and it is necessary to further verify the robustness of the simulation framework.

Sensitivity Test 1: Technical Complexity

Set the technical complexity to fluctuate within the ± 50% range, use the Monte Carlo method to generate a random uniform distribution for 200 simulation experiments, and set the random seed to 1234. Figure 4-4 presents the simulation results: with the increase in technological complexity, it shows a significant and sustained driving effect on the collaborative governance behavior between schools and enterprises. This variable exhibits good stability and has successfully passed the system sensitivity test.

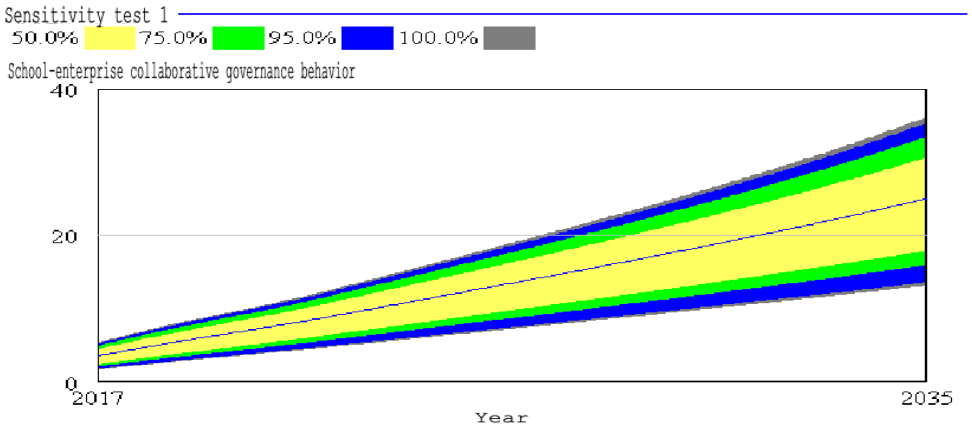


Figure 4 Sensitivity Test 1

Sensitivity Test 2: Negotiation Cost Input

Regarding the negotiation cost input level, it is also set to vary within the ± 50% range, and 200 rounds of simulation operations (random seed 1234) are performed based on the Monte

Carlo random uniform distribution principle. As shown in Figure 4-5, the increase in negotiation cost input has had a sustained and significant driving effect on the collaborative governance behavior between schools and enterprises. This variable has good stability and meets the requirements of system sensitivity testing.

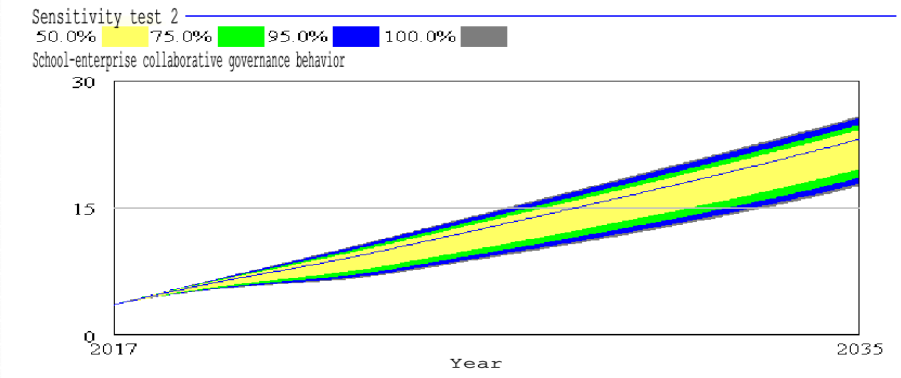


Figure 5 Sensitivity Test 2

Sensitivity Test 3: Property Rights Cost Input

The property rights cost input was varied within a ±50% range. A Monte Carlo random uniform distribution was used for 200 simulation runs, with a noise seed set to 1234. The simulation results, shown in Figure 4-6, indicate that an increase in property rights cost input exerts a strong and stable influence on school-enterprise collaborative governance behaviour. This parameter also demonstrated stable performance and passed the model sensitivity test.

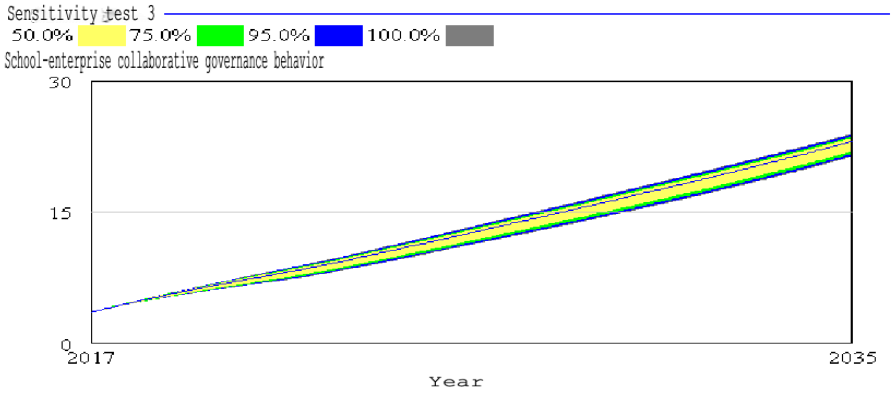


Figure 6 Sensitivity Test 3

Simulation Application of the Higher Vocational Education Collaborative Governance System Model

Following the completion of model validation, a simulation analysis was conducted to examine the impact of changes in various elements within the collaborative governance system on school-enterprise collaborative governance behaviors. The simulation period was set from 2018 to 2035 with a step length of 0.0625. First, the evolutionary trends of transaction cost-related factors, such as Information Search & Negotiation Costs and Property Rights Delineation Costs, were forecasted to assess their degree of impact on school-enterprise transaction costs. Second, the enhancing effects of the evolution of specific factors-namely Information Search Costs, Property Rights Delineation Costs, and Local Government Coordination & Participation-on school-enterprise collaborative governance behaviors were examined separately to clarify the influence intensity of each factor on collaborative behaviors. Finally, the evolutionary paths of Local Government Coordination & Participation and human capital property rights delineation were simulated to reveal their mechanisms of influence on the behaviors of local governments and skilled talents.

The study found that Information Search and Negotiation Costs had the most significant

impact on school-enterprise collaborative governance behavior, costs that permeate the entire collaborative governance process. The influence of Property Rights Delineation Costs gradually strengthened over time. An increase in Local Government Coordination & Participation demonstrated the most pronounced promotional effect on school-enterprise collaborative behavior. In contrast, while the effect of enhancing Industry Association Participation was less significant than that of local governments, it still effectively promoted collaborative behavior. This indicates that, against the backdrop of underdeveloped industry associations in China, local governments can undertake communication and coordination functions like those of industry associations through functional transformation, acting as their "functional equivalent" within the collaborative governance of higher vocational education, thereby fostering school-enterprise cooperation. Furthermore, the role of Regional Social Capital cannot be overlooked, as deeper accumulation of such capital corresponds to a stronger driving force on school-enterprise collaborative behavior.

By simulating the dynamic evolutionary trends of the higher vocational education collaborative governance system, this section further validates the main thread of the collaborative governance process. With the coordinating participation of local governments or industry organizations and the impetus of regional social capital, effectively reducing Information Search & Negotiation Costs and Property Rights Delineation Costs promotes school-enterprise collaborative governance behavior.

Discussion

These results enrich existing research on higher-vocational industry-education integration collaborative governance from descriptive, correlational and dynamic simulation perspectives.

First, the high mean scores of transaction-cost indicators in descriptive statistics remind researchers that high subjective recognition of multi-subject participation does not equal the elimination of practical institutional obstacles (Xiao & Li, 2016), which echoes transaction-cost theory that information friction and ambiguous property rights constitute core barriers to multi-party cooperation (Williamson, 1985).

Second, correlation and discriminant-validity outcomes confirm the theoretical distinction between each latent variable and verify that reducing transaction costs and strengthening multi-subject participation can jointly boost collaborative governance performance (Ansell & Gash, 2008).

Third, the pre-post comparison and differentiated growth trends obtained from system-dynamics simulation further extend previous static cross-sectional findings, confirming the functional-equivalent effect of local governments when industry associations remain underdeveloped, as well as the rising long-term value of informal factors such as regional social capital (Remington & Marques, 2020); meanwhile, the stage-specific effect of property-rights delineation costs suggests that policymakers should adopt phased governance strategies instead of one-size-fits-all measures (Fortwengel, 2017). Even if stakeholders hold positive attitudes toward school-enterprise cooperation, objective institutional frictions will still slow the progress of deep integration. Cultural identification, although with moderate contribution, serves as an indispensable soft foundation for sustaining long-run cooperation. Nevertheless, constrained by cross-sectional questionnaire data and Yunnan-centered samples, this study cannot capture real-world long-term panel changes, and future mixed-method longitudinal research is needed to further verify the generalizability of these simulation conclusions.

CONCLUSION AND DISCUSSION

Conclusion

This study adopted descriptive statistics, correlation-discriminant validity test, and system-dynamics simulation to test the research hypotheses.

1） Descriptive statistics showed that the mean values of all latent-variable indicators ranged from 3.81 to 4.10, with standard deviations between 0.60 and 0.90. Stakeholders gave high subjective evaluations for regional social capital, cultural identification, local-government coordination & participation, industry-association participation, and school-enterprise

collaborative-governance behaviors; nevertheless, high mean scores of information-search-negotiation costs and property-rights delineation costs implied that transaction-cost barriers still prevailed in real-world industry-education integration practice.

2） Pearson correlation and discriminant-validity analysis demonstrated that the square-root of AVE for each latent variable exceeded its corresponding correlation coefficients, which confirmed acceptable discriminant validity; transaction-cost variables were negatively correlated with school-enterprise collaborative-governance behaviors, while regional social capital, cultural identification, local-government coordination and participation, and industry-association participation presented positive correlations with collaborative-governance behaviors.

3） System-dynamics simulation revealed obvious differences in pre-post change and long-term growth trend among influencing factors from 2018 to 2035. After setting a 20 % improvement for each factor, local-government coordination & participation possessed the strongest growth effect, whose promotion rate rose continuously from 0.04 % to 3.52 %; industry-association participation and regional social capital also showed steady upward trends; information-search-negotiation costs exerted persistent inhibitory influence throughout the whole period; the constraint effect of property-rights delineation costs peaked in 2023 and then stabilized, whereas cultural identification maintained mild and stable contribution. Model intuitive validation, operational validation and Monte-Carlo sensitivity testing further proved that the simulation outputs were robust and reliable, and all three hypotheses of this study were supported.

Implication for Practice

This study offered the following insights for the practice of collaborative governance in higher vocational education:

Firstly, local governments need to go beyond a single administrative directive model and transform into a composite role of guides, service providers, platform builders, and institutional suppliers. Their specific performance methods should be dynamically adjusted according to the development level of local industry organizations.

Secondly, we should attach great importance to the cultivation of regional social capital and trust culture, and make the construction of informal relationship networks, cooperative reputation, and integrity systems a fundamental project to consolidate the foundation of collaborative governance in society.

Thirdly, it is necessary to accurately respond to the core concerns of enterprises and promote the transformation of enterprises from peripheral participants to strategic partners through clear property rights definition, fair profit-sharing mechanisms, and effective cost compensation arrangements.

Fourthly, policy design should accurately anchor the main contradictions at different stages of collaboration, focusing on breaking down information barriers and reducing negotiation costs in the early stages, and focusing on ensuring property stability and suppressing opportunistic behavior in the middle and later stages.

The strategic framework proposed by this research institute, especially the localization suggestions formulated around Yunnan's industrial characteristics such as "three cards", tourism culture, biomedicine, etc., can provide direct reference for deepening the integration of industry and education and innovating the training mode of skilled talents in Yunnan Province and similar regions.

Recommendation for Future Research

Future research could be further deepened and expanded in the following directions: Firstly, expand the coverage of research subjects. This study mainly focuses on public vocational colleges, and in the future, more diverse entities such as private vocational colleges and social vocational training institutions can be included in the analysis framework to explore the behavioral logic and institutional needs of different types of participants in collaborative governance.

Secondly, deepen the analysis of the institutional environment. Further empirical testing and theoretical exploration are needed to investigate how macro institutional variables such as the

division of financial powers between the central and local governments and the allocation of competitive project-based resources affect the action incentives of local governments.

Thirdly, conduct cross-regional comparative research. Different types of regions such as developed eastern regions, transitional central regions, and ethnic minority western regions can be selected for comparative analysis to more profoundly reveal the impact mechanism of regional differences on collaborative governance models and effectiveness.

Fourthly, promote the iterative cycle of policy simulation and practical feedback. Combining the system dynamics model constructed in this study with more localized and dynamic practical data, conducting long-term policy simulations, and continuously revising and improving governance strategies through tracking and evaluating the effectiveness of practice, to enhance the application value of the research.

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