

Symbiotic Collaboration between Higher Vocational Education and the Private Economy: An Empirical Analysis Using the Industry-Education Symbiosis Index

Ruoxiang Wang

Wenzhou Polytechnic, Zhejiang, Wenzhou, 325035, China

Abstract

This study investigates the coordinated development of higher vocational education and the private economy, which is important for industrial upgrading and the supply of skilled workers. However, schools are often highly motivated while companies remain indifferent, a contrast that limits the potential for collaboration between the two sides. Based on Symbiosis Theory, this paper uses standardized provincial panel data to construct an Industry-Education Symbiosis Index (IESI). The index integrates three dimensions: Networked Resource Investment (NRI), Collaborative Process Integration (CPI) and Shared Harvest Impact (SHI). It is used to empirically evaluate dynamic cooperation in Zhejiang Province from 2020 to 2024. This study finds the IESI followed a non-linear three-stage evolution and recorded a cumulative increase of 123%. However, problems remain: limited participation of small and medium-sized enterprises due to direct cost pressures, fluctuations in faculty resources caused by the evaluation system, a mismatch between talent supply and entrepreneurial demands, and unbalanced regional coordination. Drawing on Institutional Economics and Human Capital Theory, this paper proposes a three-dimensional optimization path: restructuring the symbiotic return mechanism, reforming the academic evaluation incentive system, and fostering flexible skill adaptability. These findings provide a quantifiable diagnostic tool and an actionable policy framework for transitioning from transactional cooperation to deep institutional symbiosis in transitional economies. This study advances theory by applying Symbiosis Theory to construct an empirical Industry-Education Symbiosis Index, revealing non-linear evolution patterns and persistent mismatches in industry-education collaboration. It offers a processual understanding of coordinated development between higher vocational education and the private economy, and provides a diagnostic framework for transitioning from transactional cooperation to deep institutional symbiosis in transitional economies.

Keywords

Industry-Education Integration; Higher Vocational Education; Private Economy; Symbiosis Theory.

1. Introduction

The private economy is a key pillar for advancing the Chinese path to modernization and high-quality development. Supported by the Law on Promoting the Private Economy and related policies, it has steadily shown its strength in foreign trade and technological innovation. In 2025, the total import and export volume of private enterprises reached 26.04 trillion RMB, a year-on-year increase of 7.1%. This growth contributed about 80% of the total foreign trade increase during the 14th Five-Year Plan period. Exports of high-tech products and high-end equipment rose by 14.8% and 26.9% respectively, accounting for nearly 60% of the national total for similar products. As private enterprises deeply participate in the restructuring of

global industrial and supply chains, the demand for high-quality technical and skilled talents has upgrading, thus objectively requiring precise alignment between the education chain, talent chain, and industry chain[1-5].

Higher vocational education is the main provider of technical and skilled talent. Its goals naturally align with those of the private economy. However, a persistent asymmetry has held back their combined potential. More precisely, when industry-education integration takes place, schools are usually more enthusiastic and more willing to cooperate. In contrast, companies tend to be relatively indifferent and less willing to engage. As a result, the potential for collaboration has not been fully released. Moving from simple school-enterprise cooperation to deeper industry-education integration has become an urgent task today.

Zhejiang Province offers an ideal setting for studying this dynamic. It has both a highly active private economy and a well-developed vocational education system. Private enterprises contribute over 60% of the provincial GDP, The import and export volume of its private enterprises was 4.5575 trillion RMB, making up 82.2% of the province's total foreign trade in 2025. The province also hosts the largest concentration of specialized and sophisticated SMEs in the country. At the same time, 15 higher vocational colleges in Zhejiang have been selected for the national High-level Higher Vocational Colleges and Specialty Construction Plan with Chinese Characteristics, also known as the Double High Plan[6-8].

This paper aims to build a quantitative evaluation index system. This system will be used to empirically test how the private economy and higher vocational education work together in Zhejiang. Based on the findings, we further refine a mechanism for deep integration that can be replicated and promoted elsewhere. The hope is to provide a theoretical basis and a decision-making reference for improving the regional industrial talent ecosystem and for strengthening the policy system of industry-education integration.

2. Literature Review and Theoretical Framework

(1) Integrated Review of International and Domestic Research

Internationally, the theoretical roots of industry-education integration go back to Porter's (1980) Industrial Cluster Theory and Etzkowitz's (1995) Triple Helix model. Both emphasize how universities, industries, and governments interact and support each other in a knowledge-based economy. Looking at practice, Germany's dual system highlights enterprises as central players (Euler, 2013). Australia's TAFE system adjusts its curriculum dynamically based on labor market information (Piqué, 2020). Meanwhile, US community colleges use school-enterprise alliances and competency-based education to provide customized training. Together, these models show similar features in terms of policy support, industry certification, and market-oriented operations (Song et al., 2025).

However, international research does not always fit well with China-specific conditions. These include the clustered agglomeration of the private economy and its ongoing digital transformation. Existing studies also rarely address how industry-education integration and industrial cluster upgrading interact dynamically.

Domestically, research has developed along three main lines. The first is policy-oriented studies. Early work focused on interpreting macro-level national policies (Shi, 2023). Later, researchers stressed the importance of policy implementation and incentive measures (Yuan et al., 2022). The second line is model innovation. This has moved from order-based training and modern apprenticeships to building industrial colleges (Zhou, 2024). Scholars have emphasized that enterprises should play a leading role in education, and that value symbiosis and co-growth is a key concept (Cao et al., 2023). The third line covers mechanism and evaluation research. For example, Xu et al. (2024) used Symbiosis Theory to improve benefit distribution and resource channels. Liu et al. (2024) provided empirical evidence from Wenzhou to show the need for

collaborative mechanisms. At the same time, empirical studies focused on Zhejiang reveal ongoing problems. These include a weak alignment between what academic programs offer and what industry needs, as well as mismatches between the supply of talent and actual demand (Liu, 2025).

(2) Research Gaps and This Paper's Contributions

A synthesis of the existing literature reveals three common limitations. First, most studies adopt a static perspective. Consequently, they fail to capture how industrial technological changes dynamically reshape educational demand. Second, there is a lack of enterprise-centered analysis. As a result, the internal motivational mechanisms of private enterprises behind the phenomenon of schools being eager while companies remain indifferent are insufficiently explored. Third, no quantitative evaluation tools are available. An index system that enables cross-regional and cross-temporal comparison of collaborative depth has not yet been established.

This paper addresses these gaps through three main contributions. First, Symbiosis Theory is introduced. This reframes the relationship as a dynamically evolving reciprocal system, thereby moving beyond the traditional subject-object dichotomy. Second, the Industry-Education Symbiosis Index (IESI) is constructed. This index provides methodological support for empirical research in the field and allows the collaborative level to be measured in a more quantifiable, comparable, and traceable manner. Third, based on five years of panel data from Zhejiang Provincial Department of Education, the phased characteristics and structural contradictions of the collaborative evolution are revealed. These findings offer precise targets for policy optimization.

(3) Theoretical Framework: Industry-Education Collaboration from a Symbiosis Theory Perspective

Symbiosis Theory first appeared in biology and was later used in social sciences. It refers to a mutually beneficial relationship formed when different entities exchange materials, information, and energy. In this paper, higher vocational institutions and private enterprises are seen as symbiotic units. They build a collaborative relationship through three mechanisms. The first mechanism is Networked Resource Investment (NRI), enterprises contribute production factors like equipment, capital and staff. Institutions provide educational inputs such as teachers, facilities and teaching systems. The second mechanism is Collaborative Process Integration (CPI). This involves deep interaction in teaching, training, research and development and service delivery. Such interaction allows knowledge, technology, and people to flow in both directions. The third mechanism is Shared Harvest Impact (SHI). In this stage, the talent, technology, and services produced through collaboration are fed back into the development of both sides.

The core logic of this framework is that the strength of collaboration depends on how well the three dimensions of input, process, and output interact with each other. This provides a solid theoretical basis for later indicator building and data analysis.

3. Research Design: Construction of the IESI

(1) Indicator Selection and Data Sources

To ensure that the data are validate and reliable, all indicators in this paper are taken from data set published in the Zhejiang Province Higher Vocational Education Quality Annual Report by the Zhejiang Provincial Department of Education. The data set consists of complete provincial-level statistics reported for each year from 2020 to 2024. There are no missing values or interpolated numbers.

Networked Resource Investment Index (NRI) consists of two indicators. The value of in-school practical teaching equipment provided by enterprises, reflecting the physical form of corporate capital investment. The total annual teaching hours of enterprise part-time instructors, measuring the scale of corporate human resource input. These two indicators are equally weighted, representing the capital and human resource dimensions, respectively.

Collaborative Process Integration Index (CPI) is comprises of three indicators. The proportion of Dual-qualified teachers in higher vocational institutions, reflecting the degree of school-enterprise faculty integration. The total annual remuneration for enterprise part-time instructors, representing the economic value of corporate human resource input. The number of curriculum standards developed and adopted overseas, reflecting curriculum construction quality and international recognition. These three indicators are equally weighted, covering three key process dimensions, they are faculty integration, intensity of corporate human investment, and curriculum quality.

Shared Harvest Impact Index (SHI) is made of the provincial employment rate of graduates, demonstrating the intensity of talent retention and local economic service. To be specific, the self-employment/entrepreneurship rate of graduates, reflecting the effectiveness of I&E education. the promotion rate three years after graduation, indicating the long-term career development quality of graduates.

(2) Data Standardization and Index Synthesis

To eliminate dimensional heterogeneity, a Min-Max normalization method is applied to all underlying indicators. The formula is: $X_{it}^* = (X_{it} - \min_i(X_i)) / (\max_i(X_i) - \min_i(X_i))$, where X_{it} denotes the original value of indicator i in year t , and X^* represents the normalized value (ranging from 0 to 1). Each sub-index (NRI, CPI, SHI) is synthesized by the equally weighted sum of its normalized constituent indicators. The weights assigned to the sub-indices in the composite IESI follow a progressive logic, starting from basic guarantees, moving to core processes, and culminating in educational outcomes. The final calculation formula for the IESI is established as $IESI_t = 0.3 \times NRI_t + 0.4 \times CPI_t + 0.3 \times SHI_t$.

4. Empirical Results and Analysis

(1) Trends in the Comprehensive Index

Based on the methodology, the calculated results for the IESI from 2020 to 2024 are as follows:

Table 1. The IESI results calculated during the period from 2020 to 2024

N.	YEAR	NRI	CPI	SHI	IESI
1	2020	0.1961	0.4734	0.4111	0.3715
2	2021	0.5000	0.7411	0.9146	0.7208
3	2022	0.4426	0.3908	0.6387	0.4807
4	2023	0.6620	0.2921	0.3675	0.4257
5	2024	0.9277	1.0000	0.5013	0.8287

The IESI rose steadily from 0.3715 in 2020 to 0.8287 in 2024. This represents a cumulative increase of 123% over the five-year period. Such growth indicates a major step forward in how well higher vocational education and the private economy work together in Zhejiang Province.

The index follows a three-stage pattern: a slow start, then fast growth, and finally a high-quality breakthrough. In 2020, the value was low. From 2021 to 2022, the index entered a period of rapid growth, with an average annual growth rate above 20%. Then, from 2023 to 2024, it reached a peak. The year 2024 set a new historical record[9-10].

(2) Evolution Path and Stage Characteristics

To measure how the synergy level changes over time, this paper uses a descriptive analysis. It compares the compound annual growth rate with stage-specific benchmarks. The CAGR formula is calculated as $CAGR = (V_{ending}/V_{beginning})^{(1/n-1)} - 1$, where n is the number of years. Applying the IESI data to this formula gives a CAGR of about 22.2%. This result shows that the synergy index grew at an average compound annual rate of more than 20% over the five-year period. A clear upward trend can therefore be observed.

To further identify the evolutionary pace and policy response cycles, the period from 2020 to 2024 was divided into three phases for comparative analysis of central values:

Table 2. Comparison of Core Values

STAGE	YEAR	IESI VALUE	STAGE MEAN VALUE	CORE DRIVING/LIMITING FACTORS
The Rapid Leap Stage	2020 - 2021	0.3715/ 0.7208	0.5462	The Double High Plan has been fully implemented, the benefits of innovation & entrepreneurship policies have been fully unleashed, and faculty integration has advanced rapidly.
The Fluctuating Adjustment Stage	2022 - 2023	0.4807/ 0.4258	0.4533	The evaluation criteria for dual-teacher assessments have been optimized. Curriculum standards have undergone periodic adjustments. The entrepreneurship rate has shown a phased decline.
The High-Level Break through Stage	2024	0.8287	0.8287	Corporate investments in equipment and human resources have reached a high peak. The mechanism for industry-education integration has been further strengthened. This means processes have been integrated and optimized.

The staged evolution of the IESI closely follows the policy implementation cycles of Zhejiang Province, though some delays in institutional response are observable.

The rapid rise from 2020 to 2021 matches the introduction of the Zhejiang Implementation Opinions on Deepening Industry-Education Integration (2020). This policy required enterprises to meet certain participation quotas and set up initial subsidy frameworks.

The fluctuating phase from 2022 to 2023 corresponds to a period of adjustment after the National Vocational Education Law was revised. In late 2022, the province also rolled out updated certification standards for dual-qualified teachers. These policy changes temporarily disrupted the existing evaluation system. As a result, the CPI contracted before institutional adaptation brought things back to balance.

The breakthrough in 2024 coincides with the full implementation of the Zhejiang Vocational Education Reform and High-Quality Development Action Plan (2023-2025). This plan introduced cross-regional resource pooling and pilot projects using AI-driven matching methods. At the same time, a large expansion in corporate investment and more refined process integration helped push the index clearly above previous peaks.

This non-linear progression shows that industry-education collaboration does not follow a simple straight line. Instead, it is shaped by the interaction of institutional rules, market responses, and educational cycles. Through this interplay, the overall synergy has made a substantial leap forward.

(3) Analysis of Sub-index Contributions

The standardized value of NRI rose substantially, from 0.1961 in 2020 to 0.9277 in 2024. This represents a cumulative increase of 373%. In 2024, the value of in-school practical teaching equipment provided by enterprises reached 591 million RMB, a 70.2% increase compared with 2020. At the same time, the total annual teaching hours of enterprise part-time instructors stayed at a high level of 1.725 million hours. This large increase is mainly due to the deeper implementation of the Double High Plan and the formal establishment of industry-education integration communities. The real injection of corporate capital and human resources has become the main driver behind the upward movement of the IESI.

The CPI shows a pattern of high-level oscillation followed by a rebound. It reached a high point of 0.7411 in 2021, then fell to a low of 0.2921 in 2023. This drop happened because of changes in the institutional evaluation system and adjustments to the statistical criteria for dual-qualified teachers. By 2024, the total annual remuneration for enterprise part-time instructors had increased to 158 million RMB, a rise of 22.9% from 2020. Also, the number of curriculum standards adopted overseas went above 556, setting a new record. The ups and downs of this index suggest that process integration is highly sensitive to policy alignment and to how evaluations are steered. The quick recovery in the share of dual-qualified teachers, from 72.20% in 2023 to 82.12% in 2024, shows that evaluation reforms cause short-term pain but also bring long-term gains.

The SHI rose from 0.4111 in 2020 to 0.5013 in 2024, after peaking at 0.9146 in 2021. Looking at the sub-dimensions, clear differences can be seen. For talent feedback, the provincial employment rate of graduates went up steadily from 53.62% to 66.99%. This shows a growing ability to keep talent in the province and serve the local economy. However, the graduate entrepreneurship rate fell from 4.77% to 2.41%, with declines in 2023 and 2024. This drop reflects the difficulty of linking innovation and entrepreneurship education with real market outcomes. For career development, the promotion rate three years after graduation improved from 34.07% to 39.11%. This steady gain in mid-to-long-term career growth serves as the main anchor keeping the SHI stable.

(4) Identification of Structural Contradictions

Although IESI shows a gradual upward trend, the data also reveals some potential structural issues that require close attention.

First, resource investment is unevenly distributed between leading firms and SMEs. The rise in NRI in 2024 came mainly from a large increase in equipment value. However, because short-term returns are uncertain and collaboration costs are high, many SMEs stay at the level of simple order-based training. Their deeper involvement in co-developing curricula or doing joint technological research is still limited. This suggests that the inclusiveness and overall balance of joint resource investment need to be improved.

Second, process integration is highly sensitive to evaluation systems, which can cause noticeable ups and downs. The CPI dropped sharply from 0.7411 in 2021 to 0.2921 in 2023. The main problem lies in how certification and title evaluation criteria for Dual-qualified teachers steer behavior. The share of Dual-qualified teachers fell to 72.20% in 2023, which

pulled the CPI down to its lowest point. This reflects that the old habit of valuing academic achievements over industry-education collaboration has not really changed. Compensation channels and career paths for teachers who take part in enterprise technical services are still partly blocked. As a result, school-enterprise faculty integration keeps going through cycles of ups and downs.

Third, there is a mismatch between the results of innovation and entrepreneurship (I&E) education and the supply and demand of digital skills. Within the SHI, the rate of graduates starting their own businesses fell for two years in a row, 2023 and 2024, down to 2.41%. This stands in clear contrast to the steady rise in the provincial employment rate. The data suggests that traditional program training does not fit well with the needs of new sectors like artificial intelligence and the industrial internet. Graduates have become more risk-averse, preferring stable jobs over starting a business. This skills gap, where institutional supply lags behind and companies face rising recruitment pressure, is limiting further growth of the SHI. Therefore, speeding up curriculum updates and building practical platforms for I&E are urgently needed. Fourth, regional coordination and industrial alignment should be further improved. The Hangzhou-Ningbo area benefits from a concentration of high-end industries. As a result, this region takes a leading role in exporting technical standards. In contrast, regions like Wenzhou and Taizhou have active private economies and frequent collaboration. However, their digital transformation benefits and the rate at which they turn high-quality results into practical outcomes are still relatively low. A cross-regional collaborative network that allows different areas to complement each other is missing. This weakens the overall growth momentum of the IESI. Therefore, stronger resource coordination is needed within cross-city industry-education integration communities.

5. Problem Analysis and Solution Path under Dual Constraints

(1) Academic Analysis of Core Dilemmas

Based on the data described above, the collaborative development between higher vocational education and the private economy in Zhejiang currently faces three core dilemmas.

First is the dilemma of enterprise participation motivation. Symbiosis Theory emphasizes the importance of positive benefit sharing. For small and medium-sized enterprises, there is a time lag: costs are clear and immediate, while benefits are unclear and come later. Equipment investments and payments to part-time instructors are short-term expenses. In contrast, talent adaptation and technological feedback take time to appear. As a result, collaboration often gets stuck at a shallow level. This limits how broad and how deep the NRI can go.

Next is the dilemma of institutional incentives. Institutional Economics suggests that institutions shape the behavior of individuals and firms through rules and rewards. The low point in the CPI in 2023 and the drop in the share of Dual-qualified teachers support the view that academia-focused evaluation systems are persistent. In title evaluations, the weight given to social service and technology transfer is low. This reduces teachers' internal drive to become deeply involved in industrial ecosystems. As a result, the CPI lacks a long-term institutional anchor to keep it stable.

Last dilemma is skill adaptation. Human Capital Theory stresses that education and labor markets need to stay aligned over time. The continued fall in the rate of graduates starting their own businesses, together with a flattening of the promotion rate, shows that graduates are becoming more cautious about risk. At the same time, the digital skills taught in institutions are falling behind the fast pace of industrial change. This structural mismatch lowers the added value of innovation and entrepreneurship education and also weakens the effectiveness of the SHI.

(2) Three-Dimensional Collaborative Evolution Pathways

To reconstruct symbiotic returns and resolve the enterprise participation motivation dilemma, a long-term mechanism for sharing costs and benefits should be set up. This follows the mutualism idea in Symbiosis Theory. For SMEs in regional industrial clusters such as Wenzhou and Taizhou, the mixed-ownership county-level industrial college model is worth promoting. One practical way is to use an equipment-as-equity plus targeted talent delivery method. Tax deductions for corporate spending on training equipment should be made clear. Given that Zhejiang's provincial employment rate of graduates is high at 66.99%, firms can expect a closed talent return loop. At the same time, the provincial Industry-Education Integration Smart Service Platform can be upgraded with AI capabilities. This would help match the technology needs of SMEs with the research resources of schools, lowering the costs of searching for information and trying out solutions.

To deepen evaluation system reform and resolve the process integration incentive dilemma, the old habit of one-sided academic evaluation should be changed. The incentive compatibility principle in Institutional Economics tells us that institutional rules must be reshaped. Title evaluation and performance appraisal for vocational teachers need reform. A separate track for industry-education integration is a good idea. The influence of technological breakthroughs, social services, and enterprise practice time on promotion decisions should be raised significantly. A mobility pool for Dual-qualified teachers can be set up. Also, an intelligent matching system could link the hour demands of enterprise instructors with the industry training schedules of teachers in schools. This would help calm the high-level ups and downs in the CPI that come from evaluation changes. In addition, the province could create a special subsidy fund for industry-education collaboration, giving regular rewards to school-enterprise teams that are seriously engaged in process integration.

To strengthen dynamic human capital adaptation and resolve the skill supply-demand mismatch dilemma, a skill supply and innovation-entrepreneurship ecosystem that can change with industrial development is needed. Under the flexible response principle of Human Capital Theory, region-specific actions are required. The Hangzhou-Ningbo area can use leading enterprises plus transnational industrial colleges to create advanced digital micro-credential courses. The Wenzhou-Taizhou area can adopt project-based, modular teaching so that curricula keep pace with industrial technical standards. A cross-city digital resource platform based on triple sharing should be built together, allowing online booking and shared use of high-end training equipment, industry mentor pools, and international curriculum standards. A regional I&E collaborative incubation fund is also useful, as it can combine advanced skill training with real startup projects and improve graduates see risk and return in a more long sight way.

6. Conclusion and Future Research Directions

This paper looks at how higher vocational education and the private economy have worked together in Zhejiang Province from 2020 to 2024. The analysis is based on empirical data. IESI is used in this study as a new measurement tool. The results show a non-linear, step-by-step pattern of progress. This progress has been driven by targeted policies, more investment, adjustments in teaching practices, and the buildup of successful outcomes.

Although resource co-investment and the ability to keep skilled graduates in the province have improved a lot, some problems still remain. SMEs still face barriers such as unequal participation, process instability caused by evaluation systems, a mismatch in digital skills, and unbalanced coordination across regions. By combining Symbiosis Theory with ideas from Institutional Economics and Human Capital Theory, this paper offers a practical and multi-dimensional diagnostic tool for policymakers and school leaders.

The three-dimensional path for collaborative evolution proposed in this paper includes rebuilding symbiotic returns, deepening evaluation reforms, and improving dynamic skill

adaptation. This path provides a clear and workable plan for shifting industry-education integration from simple transactional cooperation to a deeper form of institutional symbiosis. Future research could add firm-level survey data and use machine learning methods to predict how industry-education synergy might change under different economic conditions. Also, comparing results across different provinces would help test whether the IESI framework can be used in other places. Such studies would also show how local conditions shape the way industry-education collaboration works in China's varied regional economies.

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