# Undergraduate Programme Adjustment and Modern Industrial Development at the Provincial Level: An Empirical Study of Structural Alignment and Policy Coordination

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**Abstract:** Structural alignment between undergraduate programmes and industrial development affects the capacity of higher education to support regional transformation. This article examines 37 regular undergraduate institutions in one Chinese province, using administrative statistics on undergraduate programmes supplied by the provincial education authority and industrial and employment statistics supplied by the provincial statistical authority. It analyses programme distribution, graduate composition, and their relationship with industrial development. Percentage-point differences, total variation distance, and cosine similarity are used to compare graduate and employment structures, with a boundary sensitivity test for the allocation of science. Results indicate broad initial alignment: most graduates are concentrated in fields associated with the secondary and tertiary sectors. However, agriculture-related provision and graduate output remain limited; established engineering programmes require substantial renewal; some service-related programmes are widely provided but lack sufficient differentiation; university geography is uneven; and routine coordination among government, universities, and enterprises remains underdeveloped. The article recommends that government strengthen strategic planning, dynamic adjustment, differentiated evaluation, demand monitoring, and regional coordination; that universities develop new agriculture-related fields, renew established engineering and service-related programmes, translate research strengths into undergraduate education, and improve modern industry colleges; and that enterprises participate in curriculum design, practical training, programme review, and collaborative innovation. Programme adjustment should move from simple expansion and contraction towards structural optimisation, educational quality, and sustained government-university-enterprise coordination.

***Keywords*:** undergraduate programme adjustment; modern industrial development; structural alignment; policy coordination; provincial undergraduate education; industry-education integration

## 1. Introduction

Industrial restructuring and emerging sectors continually change regional needs for knowledge, technology, and human capabilities. Undergraduate programmes are an important connection between talent development and industrial change. Their distribution, scale, and educational content affect both the supply of graduates and the capacity of higher education to support regional upgrading. Provincial higher education governance must therefore consider how programme structures can respond to industrial change, improve educational quality, and enable sustained coordination among government, universities, and enterprises.

Programme adjustment concerns not only the number and composition of programmes but also curriculum content, resource allocation, and coordination arrangements. Analysis therefore needs to examine, on the one hand, the overall relationship between programme types, provision points, graduate composition, and industrial development and, on the other, programme quality, institutional geography, and the conditions for government-university-enterprise coordination. The article combines structural and policy analysis to identify the main features of programme provision and to examine how industrial change can be translated into programme and educational action.

The study examines regular undergraduate institutions in one Chinese province. The province has a broad programme base and an economy spanning agriculture, manufacturing, and diverse services. It is upgrading established industries while cultivating digital, green, health-related, and other emerging fields. At the same time, institutions and programme resources are spatially concentrated, and further improvement is required in modern agriculture, the renewal of established engineering fields, service-sector education, and industry-education collaboration.

The article addresses three questions. First, what features characterise programme provision, provision points, and graduate composition in the study province, and how do they relate to sectoral development and employment? Second, what major problems arise in agriculture-related provision, established engineering, service-related programmes, institutional geography, and government-university-enterprise coordination? Third, how should government, universities, and enterprises divide responsibilities and build a coordinated policy response for structural optimisation and educational improvement?

The article undertakes three main tasks. First, it uses administrative statistics covering all 37 regular undergraduate institutions in the province to analyse programme types, provision points, enrolment, and graduate composition. Second, it combines sectoral value added, growth contributions, employment elasticity, and employment structure to assess overall alignment and sector-specific differences, with a boundary sensitivity test for the allocation of science. Third, it uses the structural findings and policy materials to identify problems in programme development, institutional geography, and coordination, and develops recommendations for government, universities, and enterprises.

Existing research has developed along three related lines. First, supply-demand alignment studies examine how programme provision responds to social and industrial needs in scale, composition, and timing, and how curriculum, practical education, and industry-education collaboration connect graduate capabilities with work requirements (Yang, 2022; Nie et al., 2025; Addessi et al., 2025). Second, job-matching research analyses the relationship between field of study and actual employment, together with the effects of city size, population scale, and curriculum organisation (Yang & Song, 2016; Robst, 2007; Nordin et al., 2010; Abel & Deitz, 2015; Pominova & Gabe, 2023; Li et al., 2024). Third, structural-coordination research examines interaction between higher education provision, programme adjustment, and industrial restructuring at regional or system level, focusing on coordination in composition, pace, and space (Jiang et al., 2018; Yang, Wang, & Wang, 2022; Yang & Wang, 2022; Xue & Zhao, 2022).

Studies within the third line differ in object and scale. Some examine undergraduate programme structures and industrial evolution, including links with regional economic growth; some assess coordination between professional master's provision and industrial structure at a particular educational level; others analyse the relationship between the higher education structure as a whole and industrial structure, including associated economic effects (Xu & Wang, 2021; Geng & Tian, 2023). These studies provide useful measures and analytical ideas for province-level comparison, but their units of analysis, data levels, and policy implications need to be distinguished.

Research on governance mechanisms extends analysis from structural measurement to the process of programme adjustment. It examines administrative coordination, institutional autonomy, demand information, differentiated evaluation, programme entry and withdrawal, and industry-education integration. International research shows that effective work-integrated learning depends on the design of curriculum and placement processes, while durable university-industry collaboration is shaped by interaction forms, participant motivations, organisational arrangements, and realised benefits for both parties (Jackson, 2015; Ankrah & Al-Tabbaa, 2015). Chinese research likewise argues that programme governance should respond to leading, emerging, and future industries while treating short-term trends cautiously and applying differentiated approaches across institutions and fields. Programme alliances, shared laboratories, modern industry colleges, and differentiated incentives can provide institutional vehicles for government, universities, and enterprises to participate jointly in programme development (Tian, 2018; Zhang, 2023; He & Zhou, 2023; Wu & Guo, 2025; Li & Li, 2025).

Existing research has revealed multi-level relationships among programme provision, graduate employment, and industrial structure, but two areas remain underdeveloped at the provincial level. First, many studies take individual graduates, single institutions, or composite coupling indices as their unit of analysis and rarely present programme types, provision points, graduate composition, and industrial development for an entire provincial undergraduate system in the same analysis. Second, structural measurement and governance analysis are often separated, leaving limited integrated discussion of how curriculum renewal, institutional geography, and government-university-enterprise coordination jointly shape programme adjustment.

To address these gaps, the article first analyses the scale, composition, and geography of undergraduate provision, and then uses sectoral value added, employment, and related indicators to assess overall alignment and sector-specific differences. It subsequently identifies the main tensions in agriculture-related provision, established engineering, service-related programmes, spatial distribution, and coordination arrangements, before developing policy implications for government, universities, and enterprises. The boundary sensitivity test for science is used as a robustness procedure within the structural comparison to examine whether the main findings depend on this classification choice.

# 2. Case, Data, and Methods

## 2.1 Research Design, Case, and Sources

The study combines province-level structural analysis with policy analysis and examines all 37 regular undergraduate institutions and their programme portfolios in the study province. It analyses programme provision and development, sectoral development and employment, alignment between programme supply and industrial change, institutional geography, and government-university-enterprise coordination before developing policy recommendations.

The study province has an economy spanning agriculture, manufacturing, and diverse services. Its development strategy addresses the upgrading of established industries, green transition, digitalisation, and emerging sectors. Of its 37 regular undergraduate institutions, 27 are located in the provincial capital and five in another prefecture-level city, producing a marked spatial concentration of programmes and higher education resources. The combination of a broad programme base, industrial restructuring, and emerging-sector development makes the province an appropriate case for analysing the relationship between undergraduate programme adjustment and industrial development.

The empirical analysis draws mainly on three groups of materials, with the core statistical data referring to 2024. The first group consists of administrative statistics on discipline categories, major types, provision points, enrolment, and graduate output for all 37 regular undergraduate institutions. The second comprises provincial statistics on sectoral value added, contributions to economic growth, employment, and related indicators. The third consists of policy materials on industrial development, higher education reform, and industry-education platforms. The materials were used for research under restrictions on public redistribution, and identifying names of the province, subprovincial areas, and policies are anonymised in the article.

The administrative statistics are used to analyse programme types, provision points, enrolment, and graduate composition. The industrial and employment materials are used to calculate sectoral value-added shares, growth contributions, employment elasticity, and employment shares. Policy documents support the analysis of industrial priorities, programme governance, institutional geography, and industry-education collaboration. Together, the three sources provide the basis for assessing programme provision, industrial development, and policy coordination.

## 2.2 Analytical Objects and Variable Construction

Graduate shares by discipline category are converted into a three-sector graduate vector $S=(S_1, S_2, S_3)$, while the shares of employed persons in the primary, secondary, and tertiary sectors form the employment vector $E=(E_1, E_2, E_3)$. Each vector consists of three shares summing to 100 per cent and is used to examine the relationship between graduate composition and regional employment composition at the three-sector level.

Industrial development is described through three groups of indicators. Sectoral value-added shares show the scale composition of the economy; sectoral contribution rates show each sector's contribution to the increase in gross regional product; and employment elasticity relates changes in employment to changes in sectoral value added. These indicators are analysed together with major types, provision points, and graduate composition to assess overall alignment and sector-specific characteristics.

## 2.3 Discipline-to-Sector Classification and a Boundary Sensitivity Test for Science

Academic fields are classified by knowledge content and educational domain, whereas industrial sectors are classified by the nature of economic activity; the two systems do not correspond directly (UNESCO Institute for Statistics, 2014; United Nations, 2008). To compare graduate and employment structures at the three-sector level, the analysis assigns agriculture to the primary sector, engineering to the secondary sector, and philosophy, economics, law, education, literature, history, medicine, management, and arts to the tertiary sector, while treating science through two allocation boundaries. This rule converts graduate data by discipline category into a proportional structure comparable with sectoral employment.

Science is selected for the boundary sensitivity test for two reasons. First, the 2024 Chinese undergraduate programme catalogue includes mathematics, physics, chemistry, geographical sciences, biological sciences, statistics, and related fields within science. These knowledge areas provide scientific and analytical capabilities for secondary-sector activities such as manufacturing, energy, and materials, while also entering tertiary-sector activities such as information technology, research and technical services, education, and health (Ministry of Education, 2024; National Bureau of Statistics of China, 2018). Second, changing only the allocation of science while holding all other classifications constant allows changes in the results to be linked clearly to this treatment.

Given the contribution of science to both secondary- and tertiary-sector activities, the analysis uses two boundaries: all science graduates are assigned to the secondary sector at one boundary and to the tertiary sector at the other, with all remaining discipline classifications held constant. The two boundaries cover the two extreme treatments of science across these sectors. Comparing graduate structures, sectoral differences, and aggregate indicators at both boundaries shows how stable the principal structural findings remain when the allocation of science changes to its maximum extent (Saltelli et al., 2008).

## 2.4 Structural Comparison Measures

- Three descriptive measures compare graduate and employment structures. First, the percentage-point difference is defined as:

$$\Delta_i = S_i - E_i, i = 1, 2, 3$$

where $S_i$ is the graduate share associated with sector i and $E_i$ is the employment share. The measure reports the direction and magnitude of the difference in each sector: a positive value indicates a higher graduate share than employment share, and a negative value indicates a lower graduate share.

- Second, cosine similarity is defined as:

$$\mathrm{CosSim}(\mathbf{S}, \mathbf{E}) = \frac{\sum_{i=1}^{3} S_i E_i}{\sqrt{\sum_{i=1}^{3} S_i^2}\sqrt{\sum_{i=1}^{3} E_i^2}}$$

Cosine similarity ranges from 0 to 1, with larger values indicating greater similarity in the relative three-sector distribution (Salton et al., 1975).

- Third, total variation distance is defined as:

$$\mathrm{TVD}(\mathbf{S}, \mathbf{E}) = \frac{1}{2}\sum_{i=1}^{3} |S_i - E_i|$$

Total variation distance ranges from 0 to 1: 0 indicates identical distributions, and larger values indicate a greater overall absolute difference (Gibbs & Su, 2002). Percentage-point differences locate the sectors in which differences occur, cosine similarity summarises the overall distributional direction, and total variation distance summarises the overall magnitude of difference.

### 2.5 Analytical Procedure

The analysis proceeds in five steps. First, it examines discipline categories, provision points, enrolment, graduate composition, institutional geography, and disciplinary and research strengths to describe programme supply. Second, it analyses sectoral value-added shares, contribution rates, employment elasticity, and employment composition to identify the scale, growth, and employment characteristics of each sector. Third, it constructs the three-sector graduate structure using the classification above, calculates percentage-point differences, cosine similarity, and total variation distance, assesses overall alignment and sector-specific differences, and compares the two science-allocation boundaries. Fourth, it uses evidence on programme development, institutional geography, and government-university-enterprise collaboration to identify the main adjustment problems. Fifth, it develops recommendations around the responsibilities of government, universities, and enterprises.

## 3. Findings: Programme Provision, Industrial Development, and Structural Alignment

### 3.1 Broad Coverage alongside Concentration and Repeated Provision

By the end of 2024, regular undergraduate institutions in the study province had added or optimised 52 major types and withdrawn 57. Excluding military science and interdisciplinary studies, the system contained 12 discipline categories, 87 major categories, 368 major types, and 2,380 provision points. The range of provision was broad, but major types, provision points, and graduates were concentrated in engineering, management, and arts. Engineering accounted for 34.24 per cent of major types, 32.48 per cent of provision points, and 34.93 per cent of graduates. Management and arts accounted for 14.87 and 11.97 per cent of provision points and 13.56 and 11.36 per cent of graduates, respectively. Agriculture accounted for 7.34 per cent of major types but only 2.94 per cent of provision points and 2.17 per cent of graduates.

**Table 1. Undergraduate major structure and scale in the study province, 2024**

| Sector | Discipline category | Major types | Major types (%) | Institutions | Provision points | Points (%) | Mean points per major | Graduate share (%) |
|---|---|---|---|---|---|---|---|---|
| Primary | Agriculture | 27 | 7.34 | 10 | 70 | 2.94 | 2.59 | 2.17 |
| Secondary | Science | 23 | 6.25 | 24 | 161 | 6.76 | 7.00 | 6.40 |
| Secondary | Engineering | 126 | 34.24 | 35 | 773 | 32.48 | 6.13 | 34.93 |

| Sector | Discipline category | Major types | Major types (%) | Institutions | Provision points | Points (%) | Mean points per major | Graduate share (%) |
|---|---|---|---|---|---|---|---|---|
| Tertiary | Philosophy | 1 | 0.27 | 2 | 4 | 0.17 | 4.00 | 0.06 |
| Tertiary | Economics | 16 | 4.35 | 26 | 102 | 4.29 | 6.38 | 4.53 |
| Tertiary | Law | 19 | 5.16 | 22 | 90 | 3.78 | 4.74 | 3.56 |
| Tertiary | Education | 18 | 4.89 | 19 | 114 | 4.79 | 6.33 | 5.68 |
| Tertiary | Literature | 34 | 9.24 | 32 | 251 | 10.55 | 7.38 | 9.81 |
| Tertiary | History | 4 | 1.09 | 8 | 19 | 0.80 | 4.75 | 0.66 |
| Tertiary | Medicine | 30 | 8.15 | 14 | 157 | 6.60 | 5.23 | 7.29 |
| Tertiary | Management | 35 | 9.51 | 37 | 354 | 14.87 | 10.11 | 13.56 |
| Tertiary | Arts | 35 | 9.51 | 31 | 285 | 11.97 | 8.14 | 11.36 |
| Total | 12 categories | 368 | 100.00 | 37 | 2,380 | 100.00 | 6.47 | 100.00 |

Note: Administrative data cover all 37 regular undergraduate institutions. Graduate shares are calculated from the administrative graduate totals. The sector column is presented at the boundary where science is assigned to the secondary sector; results with science assigned to the tertiary sector are reported in Table 5. Percentages may not sum exactly to 100 because of rounding.

Each major was offered at an average of 6.47 provision points, and some fields combined broad institutional coverage with small cohorts at each point. English and Computer Science and Technology were each offered by 29 institutions, an institutional coverage rate of 78.38 per cent. Data Science and Big Data Technology, Marketing, and Environmental Design each reached 72.97 per cent, and Visual Communication Design reached 70.27 per cent. Mean enrolment per provision point was only 23 in Marketing, 24 in Korean, and 42 in both International Economics and Trade and Japanese. Taken together, coverage and cohort size reveal repeated provision, small-scale points, and limited differentiation in some fields, making consolidation, redesign, and quality improvement important priorities.

**Table 2. Majors with broad institutional coverage in the study province, 2024**

| Rank | Major | Institutions | Provision points | Enrolment | Institution coverage (%) | Mean enrolment per institution | Mean enrolment per point |
|---|---|---|---|---|---|---|---|
| 1 | English | 29 | 47 | 3,352 | 78.38 | 116 | 71 |
| 2 | Computer Science and Technology | 29 | 59 | 5,874 | 78.38 | 203 | 100 |
| 3 | Data Science and Big Data Technology | 27 | 34 | 1,674 | 72.97 | 62 | 49 |
| 4 | Marketing | 27 | 38 | 875 | 72.97 | 32 | 23 |
| 5 | Environmental Design | 27 | 40 | 2,172 | 72.97 | 80 | 54 |
| 6 | Visual Communication Design | 26 | 31 | 1,875 | 70.27 | 72 | 60 |
| 7 | Financial Management | 24 | 40 | 2,685 | 64.86 | 112 | 67 |
| 8 | Japanese | 23 | 27 | 1,135 | 62.16 | 49 | 42 |
| 9 | International Economics and Trade | 20 | 25 | 1,060 | 54.05 | 53 | 42 |
| 10 | Electronic Information Engineering | 20 | 24 | 1,706 | 54.05 | 85 | 71 |
| 11 | Software Engineering | 19 | 21 | 1,518 | 51.35 | 80 | 72 |
| 12 | Accounting | 19 | 35 | 3,547 | 51.35 | 187 | 101 |
| 13 | Business Administration | 18 | 31 | 1,331 | 48.65 | 74 | 43 |
| 14 | Mechanical Design, Manufacturing and Automation | 17 | 30 | 2,886 | 45.95 | 170 | 96 |
| 15 | Chinese Language and Literature | 17 | 36 | 3,899 | 45.95 | 229 | 108 |
| 16 | Electrical Engineering and Automation | 17 | 36 | 4,114 | 45.95 | 242 | 114 |
| 17 | Automation | 16 | 19 | 1,542 | 43.24 | 96 | 81 |
| 18 | Mathematics and Applied Mathematics | 16 | 21 | 1,622 | 43.24 | 101 | 77 |
| 19 | Tourism Management | 16 | 18 | 846 | 43.24 | 53 | 47 |
| 20 | Korean | 16 | 21 | 503 | 43.24 | 31 | 24 |

Note: Institutional coverage is the number of institutions offering a major divided by the province's 37 regular undergraduate institutions. Provision points and mean enrolment per point are reported together to examine repeated provision and cohort scale.

Institutional geography was also highly concentrated. Of the 37 regular undergraduate institutions, 27 were located in the provincial capital and five in another prefecture-level city, together accounting for 86.49 per cent; three prefecture-level areas had no regular undergraduate institution. This distribution, combined with the spatial separation of some campuses and relevant industrial parks, raises the organisational costs of shared laboratories, faculty industry practice, student placements, and sustained collaboration, and reduces the ease with which distinctive industries outside the main centres can access university talent and innovation resources.

## 3.2 Translating Disciplinary and Research Strengths into Undergraduate Education

The study province has a substantial base of disciplinary and research strength. By the end of 2024, 13 disciplines had been selected for national Double First-Class construction, 53 disciplines across 11 institutions were ranked in the top 1% globally in Essential Science Indicators, five were in the top 1 per mille, and the province had 120 national speciality majors and 20 self-established interdisciplinary disciplines. These indicators show recognised research capability and pockets of national competitiveness.

These disciplinary and research platforms provide an important basis for curriculum renewal, interdisciplinary education, and industrial innovation. Their contribution can be strengthened by embedding research more systematically in undergraduate courses, laboratory and field practice, and student research, with particular attention to interdisciplinary pathways in smart agriculture, advanced materials, artificial intelligence, green manufacturing, and data-intensive services.

## 3.3 Sectoral Development and Employment Structure

In 2024, the province's value-added structure followed a tertiary-secondary-primary pattern: the tertiary sector accounted for 57.05 per cent, the secondary sector 31.87 per cent, and the primary sector 11.07 per cent. Table 3 reports the graduate structure at the boundary where science is assigned to the secondary sector; results for the tertiary-sector boundary appear in Section 3.5. Calculations based on provincial statistics give sectoral contribution rates of -13.16, 36.03, and 77.13 per cent and employment elasticities of 0.41, -1.00, and 0.15, respectively.

**Table 3. Sectoral development indicators and undergraduate programme structure, 2024 (science assigned to the secondary sector)**

| Sector | Value-added share (%) | Major-type structure (%) | Contribution rate (%) | Employment elasticity | Employment structure (%) | Graduate structure (%) |
|---|---|---|---|---|---|---|
| Primary | 11.07 | 7.34 | -13.16 | 0.41 | 38.31 | 2.17 |
| Secondary | 31.87 | 40.49 | 36.03 | -1.00 | 14.67 | 41.33 |
| Tertiary | 57.05 | 52.17 | 77.13 | 0.15 | 47.02 | 56.50 |

Note: Sectoral value-added, economic-growth, and employment data are drawn from provincial statistical materials. Value-added shares, contribution rates, and employment elasticity are calculated from the reported data. The graduate structure assigns science to the secondary sector.

Taken together, the indicators show that the tertiary sector was the largest sector in economic scale, growth contribution, and employment. The secondary sector accounted for almost one third of value added and contributed 36.03 per cent of growth, but its employment elasticity of -1.00 indicates simultaneous industrial growth and employment contraction as production became more technology- and capital-intensive. The primary sector employed 38.31 per cent of workers but produced 11.07 per cent of value added and made a negative growth contribution, indicating a high employment burden and a substantial productivity challenge. The provincial economy thus combined tertiary-sector leadership, secondary-sector support, and accelerated primary-sector transformation, while facing high primary-sector employment, declining employment absorption in the secondary sector, and limited incremental job creation in services.

## 3.4 Overall Alignment and Sector-Specific Differences

Programme types and graduate composition also followed a tertiary-secondary-primary pattern, broadly corresponding to the direction of the value-added structure. At the boundary where science is assigned to the secondary sector, programmes associated with the secondary and tertiary sectors accounted for 92.66 per cent of major types and 97.83 per cent of graduates. Cosine similarity between graduate and employment structures was 0.766 and total variation distance was 0.361. The broad centres of programme provision and industrial development therefore corresponded, while sector-specific differences revealed substantial local misalignment.

Table 4. Structural comparison at the science-to-secondary boundary

| Sector | Graduate share S_i (%) | Employment share E_i (%) | Percentage-point difference $\Delta_i$ | Interpretation |
|---|---|---|---|---|
| Primary | 2.17 | 38.31 | -36.14 | 36.14 pp lower |
| Secondary | 41.33 | 14.67 | +26.66 | 26.66 pp higher |
| Tertiary | 56.50 | 47.02 | +9.48 | 9.48 pp higher |

Note: $\Delta_i=S_i-E_i$. Positive values indicate a higher graduate share than employment share, and negative values indicate a lower graduate share. Cosine similarity summarises the overall distributional direction and total variation distance the overall absolute difference.

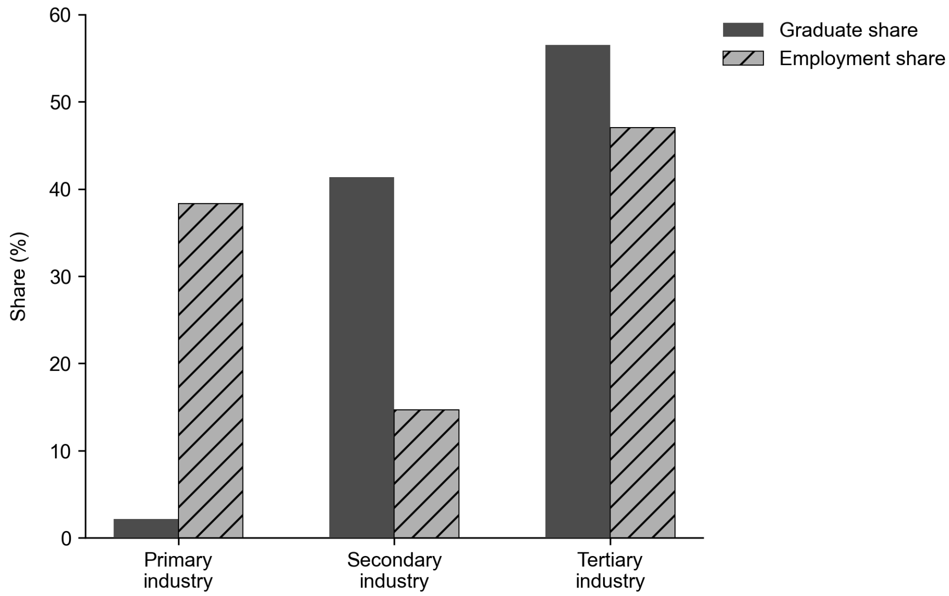


**Figure 1. Graduate and employment structures at the science-to-secondary boundary, 2024**

The primary sector had the largest absolute percentage-point difference, at -36.14. Agriculture accounted for 7.34 per cent of major types, 2.94 per cent of provision points, and 2.17 per cent of graduates. Relative to the sector's importance in provincial employment and agricultural development, agriculture-related undergraduate provision was clearly weak. Programme development needs to extend from conventional agronomy to agricultural engineering, intelligent equipment, data, food processing, management, branding, supply chains, and rural public services, creating capabilities across the modern agricultural value chain.

The secondary-sector difference was +26.66 percentage points. Science and engineering together accounted for 41.33 per cent of graduates, compared with 14.67 per cent of employment, demonstrating a substantial science and engineering education base. Negative employment elasticity indicates that sectoral growth did not produce a parallel expansion in employment and was instead associated with technological and capital deepening. In this context, programme adjustment should move beyond expanding graduate volume towards upgrading educational content and capability structures. Established engineering programmes need faster renewal in intelligent, green, and digital directions and stronger curriculum and practice links with new energy, advanced materials, artificial intelligence, industrial software, and systems engineering.

The tertiary-sector difference was +9.48 percentage points, the smallest absolute difference among the three sectors. Service-related disciplines accounted for 52.17 per cent of major types and 56.50 per cent of graduates, broadly corresponding to the sector's 57.05 per cent share of value added and 47.02 per cent share of employment. At the same time, management, arts, and literature had many provision points, and Table 2 shows that several service-related majors combined wide coverage with small cohorts. Optimisation should therefore focus on curriculum distinctiveness, digital capability, practical education, and educational quality.

## 3.5 Stability across the Two Science-Allocation Boundaries

When all science graduates are assigned to the secondary sector, the graduate shares associated with the primary, secondary, and tertiary sectors are 2.17, 41.33, and 56.50 per cent; when science is assigned to the tertiary sector, the shares are 2.17, 34.93, and 62.90 per cent. Total variation distance is 0.361 at both boundaries, while cosine similarity is 0.766

and 0.791, respectively. The allocation of science changes the specific secondary- and tertiary-sector graduate shares and the cosine-similarity value; both boundaries show clearly weak agriculture-related provision and a high concentration of graduates in fields associated with the secondary and tertiary sectors. The central conclusions remain stable.

**Table 5. Structural comparison across the two science-allocation boundaries**

| Science-allocation boundary | Graduate shares: primary / secondary / tertiary (%) | Cosine similarity | Total variation distance |
|---|---|---|---|
| All science assigned to secondary sector | 2.17 / 41.33 / 56.50 | 0.766 | 0.361 |
| All science assigned to tertiary sector | 2.17 / 34.93 / 62.90 | 0.791 | 0.361 |

Note: Employment shares are 38.31% primary, 14.67% secondary, and 47.02% tertiary. Higher cosine similarity indicates closer overall direction; lower total variation distance indicates a smaller aggregate absolute difference.

# 4. Discussion: Structural Tensions and Coordination Challenges

## 4.1 Weak Agriculture-Related Provision

Agriculture accounted for 7.34 per cent of major types, 2.94 per cent of provision points, and 2.17 per cent of graduates, while the primary sector employed 38.31 per cent of the workforce and remains central to the province's industrial base and modernisation. The scale of agriculture-related provision and graduate output falls well short of the needs associated with agricultural upgrading and food-value-chain development. Agriculture-related education also requires stronger integration with intelligent equipment, data, food science, management, branding, and supply-chain capabilities.

## 4.2 A Large Engineering Base but Insufficient Renewal

Engineering accounted for 34.24 per cent of major types, 32.48 per cent of provision points, and 34.93 per cent of graduates, making it the core of provincial undergraduate provision. Negative employment elasticity in the secondary sector indicates strong technological and capital substitution during industrial growth. The province has a large engineering base, but integration of established curricula with intelligent manufacturing, new energy, advanced materials, industrial software, and green production remains incomplete, limiting the conversion of programme scale into capability for industrial upgrading.

## 4.3 Wide Service-Related Provision but Limited Distinctiveness and Quality

Management, arts, literature, and other service-related disciplines accounted for large shares of provision and graduates. Marketing, Tourism Management, International Economics and Trade, Japanese, and Korean also combined broad institutional coverage with relatively small cohorts. Although services dominate both output and employment, the sector includes education, health, culture and tourism, digital services, and commerce. Some service-related programmes remain weak in curriculum distinctiveness, digital application, practical education, and regional industrial connection, creating an imbalance between expansion and educational substance.

## 4.4 Weak Spatial Alignment between Institutions and Regional Industry

A total of 86.49 per cent of regular undergraduate institutions were located in the provincial capital and another prefecture-level city, three prefecture-level areas had no regular undergraduate institution, and some campuses were poorly aligned with industrial parks. This geography limits the faculty, laboratory, placement, and innovation resources available to areas outside the main centres and constrains sustained interaction between programme development and distinctive local industries.

## 4.5 The Absence of a Durable Coordination Mechanism

Government-university-enterprise collaboration is organised mainly through individual projects, placement agreements, modern industry colleges, and targeted funds. These arrangements provide an existing base, but industrial information, programme decisions, and educational processes are not yet connected through a stable institutional routine. Regular consultation, information sharing, responsibility allocation, and outcome review remain underdeveloped; incentives for university regional service are limited, and the depth of enterprise participation in curriculum, practical education, programme evaluation, and collaborative innovation varies across institutions and fields.

# 5. Policy Implications for Programme Adjustment and Industrial Development

Alignment requires a combination of government coordination, active institutional responsibility, and meaningful enterprise participation. Government should improve institutions and coordinate public resources; universities should renew programme structures and educational content in accordance with their missions; and enterprises should contribute demand information, practical education, and collaborative innovation. The shared objective is to move programme development beyond scale expansion towards structural optimisation and educational quality.

## 5.1 Government: Strengthen Strategic Design and Planning Coordination

### 5.1.1 Improve Dynamic Adjustment and Differentiated Incentives

First, establish mechanisms for joint development and resource sharing. Around leading, established, and emerging industries, government can support alliances in foundational and applied fields, shared laboratories, practice bases, and data platforms. Where an individual institution cannot sustain a field that the region requires, joint teaching, shared curricula, staff exchange, and collaborative facilities can reduce costs and improve quality.

Second, improve monitoring, warning, adjustment, and withdrawal. Programmes with persistent problems in enrolment, educational quality, or graduate development should first undergo diagnosis and improvement, followed where necessary by enrolment adjustment, curriculum redesign, resource integration, suspension, or withdrawal based on multi-year evidence. Programmes serving leading, emerging, future, or long-term strategic fields can receive developmental or protective support. Governance should reflect institutional differentiation, avoid indiscriminate pursuit of short-lived industrial attention, and avoid uniform withdrawal of established programmes.

Third, use differentiated evaluation and resource incentives. Research-intensive universities can be evaluated on foundational research, frontier interdisciplinarity, and the translation of research into undergraduate learning. Applied institutions can be evaluated on engagement with leading industries, practical curricula, technology services, and the quality of customised education. Other institutions should be evaluated in relation to their distinct missions and public-service roles. Funding should support modern agriculture, the renewal of established engineering, new engineering, digital capabilities, and other strategic fields while considering programme distinctiveness, collaboration quality, and student outcomes.

### 5.1.2 Establish Talent-Demand Monitoring and Forecasting

A provincial talent supply-demand platform can regularly assemble and communicate information on workforce scale, occupational composition, capability requirements, and changes in key industries, linking these materials with programme, enrolment, and graduate statistics. Industrial planning and programme planning should be connected through recurrent assessments of regional alignment and through information on urgent fields, priority areas, and emerging risks.

Demand forecasting should combine statistical materials, enterprise surveys, vacancy information, technology roadmaps, and graduate tracking. Continuing sector studies can clarify the knowledge, capability, and qualification requirements of new energy, advanced materials, biomedicine, digital technologies, and other frontier fields. Big data and artificial intelligence can support information processing and trend analysis, while the results should be reviewed together with institutional capacity, educational lead times, and student development and translated into differentiated programme-adjustment recommendations.

### 5.1.3 Strengthen Industry-Education Integration and Regional Coordination

Government can use tax, project, and platform instruments to encourage enterprise participation in curriculum, practical education, accreditation, research, and technology transfer. Coordination among education, development and reform, industry and information, human resources, and statistical departments can improve data sharing, policy alignment, and project coordination. Modern industry colleges, programme alliances, and joint laboratories should have clear objectives, operating responsibilities, and evaluation standards centred on educational quality, enterprise participation, and innovation outcomes.

Programme geography should also reflect regional differences. Areas with distinctive strengths in agriculture, clean energy, tourism, or specialised manufacturing can support joint programme directions and practice bases. Areas with limited undergraduate provision can extend access through local partnerships, inter-institutional cooperation, remote curricula, and shared facilities. Campus development, industrial-park planning, and public training infrastructure should be coordinated to improve the spatial conditions for collaboration.

## 5.2 Universities: Strengthen Programme Content and Educational Quality

### 5.2.1 Optimise Programme Structures in Response to Industrial Change

Universities should renew programmes and curricula in relation to concrete capabilities required by industrial transformation. Agriculture-related education can connect agronomy with intelligent equipment, food science, agricultural processing, branding, and supply-chain management. Established engineering should incorporate intelligent, green, and digital technologies and strengthen links with new energy, advanced materials, and artificial intelligence. Tourism, business, cultural, and other service-related fields can integrate digital technologies and data analysis into curricula, practice, and entrepreneurship while maintaining disciplinary substance.

In fields with rapidly changing demand and emerging technological trajectories, universities can begin with microprogrammes, minors, short modules, or cross-school pathways and decide on expansion after reviewing teaching quality and student development. Such initiatives should have clear learning objectives, qualified teaching teams, coherent curricula, and evaluation rules so that rapid response remains grounded in complete educational design.

#### 5.2.2 Improve Programme Quality and Institutional Distinctiveness

Universities should translate research strengths and facilities more fully into undergraduate learning. Major laboratories, research teams, and high-performing disciplines can contribute through research-led modules, authentic projects, shared equipment, interdisciplinary supervision, and student research. Foundational science, agriculture, and established engineering fields with accumulated strategic value should retain necessary capacity while continuously updating their educational content.

Institutions should develop key, advantageous, and distinctive programme clusters in accordance with their missions, sharing foundational curricula, laboratories, and staff where appropriate. Programmes with extensive but homogeneous provision require stronger quality review and redesign. Small fields serving critical industries, public services, or disciplinary continuity can be supported through joint provision and inter-university collaboration to avoid the loss of essential capability.

#### 5.2.3 Improve the Effectiveness of Modern Industry Colleges and Comparable Platforms

Modern industry colleges and related platforms should integrate talent development, faculty practice, student placements, innovation, applied research, and knowledge transfer. Enterprises should participate in programme design, curricula, textbooks, and teaching so that content is connected with technical standards, production processes, and project development. Customised cohorts, joint enterprise modules, and industry mentors can help students understand real working environments.

Universities should establish an internal consultation mechanism linking programme provision with industrial demand. Academic affairs, discipline planning, research, and careers units should regularly consult enterprises and sector organisations on curriculum renewal, programme adjustment, and practice bases. Evaluation of modern industry colleges should focus on the depth of enterprise participation, curriculum and teaching change, student practice, technological innovation, and knowledge application, shifting attention from numerical expansion to educational and innovation outcomes.

### 5.3 Enterprises: Develop Talent and Innovation

#### 5.3.1 Adopt a Strategic Approach to Talent and Participate throughout Education

Enterprise participation in university education is both a social responsibility and part of long-term workforce strategy. Firms can contribute industry employment information, capability standards, and technology trends to programme review and curriculum design. Where conditions permit, they can provide supervised placements, co-develop customised cohorts, and offer students sustained exposure to real work environments.

Enterprise engineers and managers can serve as industry mentors or part-time teachers, bringing current standards, processes, and management experience into education. Enterprises can also include their educational investment and outcomes in social-responsibility reporting or internal evaluation, helping collaboration move from temporary activity towards a more stable arrangement.

#### 5.3.2 Use Innovation and Market Demand to Support Programme Development

Enterprises should connect with university research and talent resources during their own technological upgrading. Joint projects can convert production, technical, and organisational problems into research questions, curriculum cases, and student projects. A process in which enterprises pose problems, universities organise inquiry, and markets assess outcomes can allow industrial feedback and technological results to support programme development.

Enterprises should also participate in programme evaluation, curriculum development, and practical teaching standards through sector committees and related platforms. Where distance, safety, or equipment conditions restrict practice, virtual simulation, remote operation, and digital production environments can supplement placements, provided that they include real guidance, process assessment, and necessary in-person experience.

### 5.4 Strengthen Coordinated Implementation and Outcome Review

Government, universities, and enterprises should establish recurrent consultation and clear responsibility lists covering demand information, programme decisions, curriculum development, practical education, student protection, and data use. A provincial evaluation mechanism can examine programme-structure change, educational quality, graduate development, enterprise participation, innovation, and regional service without allowing a single employment indicator or project count to determine judgement.

New programmes, programme renewal, modern industry colleges, and regional platforms should be monitored and reviewed periodically, with support adjusted in response to implementation. Evaluation should inform both programme entry and withdrawal and identify concrete needs in curriculum, staffing, facilities, and collaboration, creating a cycle that connects demand monitoring, implementation, feedback, and subsequent adjustment.

## 6. Conclusion

This article examined structural alignment between undergraduate programme adjustment and modern industrial development at the provincial level. Using administrative statistics covering all 37 regular undergraduate institutions and provincial industrial and employment statistics, it found that programme provision and graduate composition broadly corresponded to the tertiary-secondary-primary structure of the economy, with graduates concentrated mainly in fields associated with the secondary and tertiary sectors. The main local problems were weak agriculture-related provision, incomplete conversion of the large engineering base into industrial-upgrading capability, widespread but insufficiently distinctive service-related provision, weak spatial alignment between institutions and regional industry, and the absence of a durable government-university-enterprise coordination mechanism. These findings remained stable when science was assigned to either the secondary or tertiary sector.

Policy should move programme governance beyond numerical expansion and contraction towards structural optimisation and educational quality. Government should improve dynamic adjustment, differentiated evaluation, resource incentives, demand monitoring, and spatial coordination. Universities should strengthen modern agriculture, renew established engineering and service-related education, translate research resources into undergraduate learning, and improve the educational performance of modern industry colleges. Enterprises should make talent development a long-term responsibility and participate in curriculum, practice, programme evaluation, and collaborative innovation. Regular consultation, clear responsibilities, and outcome evaluation are required across all three actors.

Future research can build on this province-level structural analysis by combining graduate tracking, enterprise vacancy surveys, qualification-specific employment statistics, and multi-year data to refine assessments in particular programme areas and to evaluate the effects of programme adjustment, curriculum renewal, and industry-education policies over time.

## Appendix A. Discipline-to-Sector Classification Rules

Appendix Table A1 reports the discipline-to-sector rule and the two boundaries for allocating science. All other discipline categories are classified identically at the two boundaries. The table documents the calculation rules for structural conversion and the boundary sensitivity test.

**Table A1. Discipline-to-sector classification rule and science-allocation boundaries**

| Discipline category | Science-to-secondary boundary (P/S/T) | Science-to-tertiary boundary (P/S/T) |
|---|---|---|
| Agriculture | 1.00 / 0.00 / 0.00 | 1.00 / 0.00 / 0.00 |
| Science | 0.00 / 1.00 / 0.00 | 0.00 / 0.00 / 1.00 |
| Engineering | 0.00 / 1.00 / 0.00 | 0.00 / 1.00 / 0.00 |
| Philosophy | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Economics | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Law | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Education | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Literature | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| History | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Medicine | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Management | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |
| Arts | 0.00 / 0.00 / 1.00 | 0.00 / 0.00 / 1.00 |

Note: P = primary sector, S = secondary sector, and T = tertiary sector. The two columns differ only in the allocation of science and are used to calculate graduate structures at the two boundaries.

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## Disclosure Statement

The authors declare no competing interests.

## Declaration of Generative AI Use

Generative AI tools were used to support translation, language editing, structural revision, and consistency checks. The authors retain responsibility for the conceptual framework, data treatment, classification assumptions, analytical decisions, interpretation, policy propositions, source verification, and final wording.

## Data Availability Statement

The study uses administrative statistics on undergraduate programmes supplied by the provincial education authority and industrial and employment statistics supplied by the provincial statistical authority. The underlying materials were provided for research use under restrictions that prevent public redistribution and are not publicly available; access or verification requires permission from the relevant data providers. The article reports the aggregate values required to reproduce the principal calculations. The two science-allocation boundaries are reported in Table 5 and the complete classification rule in Appendix A.

## References


[1] Abel, J. R., & Deitz, R. (2015). Agglomeration and job matching among college graduates. Regional Science and Urban Economics, 51, 14–24. https://doi.org/10.1016/j.regsciurbeco.2014.12.001

[2] Addessi, W., Biagi, B., Ciucci, L., Detotto, C., & Pulina, M. (2025). Exploring the misalignment between HEIs' educational offerings and the local economy in low(er) income regions. Regional Studies, 59(1), Article 2358827. https://doi.org/10.1080/00343404.2024.2358827

[3] Ankrah, S., & Al-Tabbaa, O. (2015). Universities–industry collaboration: A systematic review. Scandinavian Journal of Management, 31(3), 387–408. https://doi.org/10.1016/j.scaman.2015.02.003

[4] Geng, M., & Tian, H. (2023). Coordination between higher education and industrial structure and its economic effects: An empirical analysis based on provincial panel data and a spatial Durbin model. Chongqing Higher Education Research, 11(3), 64–78.

[5] Gibbs, A. L., & Su, F. E. (2002). On choosing and bounding probability metrics. International Statistical Review, 70(3), 419–435. https://doi.org/10.1111/j.1751-5823.2002.tb00178.x

[6] He, Z., & Zhou, J. (2023). Strengthening the adjustment and optimisation of disciplines and majors to advance higher education modernisation. China Higher Education, (15/16), 20–23.

[7] Jackson, D. (2015). Employability skill development in work-integrated learning: Barriers and best practice. Studies in Higher Education, 40(2), 350–367. https://doi.org/10.1080/03075079.2013.842221

[8] Jiang, L., Li, Y., & Dong, W. (2018). Interaction and co-evolution between higher education structure and industrial structure in China: A systems-coupling perspective. Education Science, 34(3), 59–66.

[9] Li, H., Cao, F., & Dai, W. (2024). Major-based undergraduate curriculum as an obstacle to graduate employability development. Higher Education Research & Development, 43(3), 705–719. https://doi.org/10.1080/07294360.2023.2258844

[10] Li, J., & Li, L. (2025). Optimising university disciplines and majors in the context of new quality productive forces: Values, practical constraints, and pathways. University Education Science, (3), 52–60.

[11] Ministry of Education of the People's Republic of China. (2024, March 19). Catalogue of undergraduate programmes in regular higher education institutions (2024). Available from: https://www.moe.gov.cn/srcsite/A08/moe_1034/s4930/202403/t20240319_1121111.html

[12] National Bureau of Statistics of China. (2018, March 27). Notice on revising the Regulations on the Classification of the Three Industries (2012). Available from: https://www.stats.gov.cn/sj/tjbz/gjtjbz/202302/t20230213_1902764.html

[13] Nie, F., Jiang, H., Lin, K., & Lin, J. (2025). Dynamic adjustment mechanisms and key pathways for university disciplines and majors under new quality productive forces. Yanjiusheng Jiaoyu Yanjiu, (5), 85–92. https://doi.org/10.19834/j.cnki.yjsjy2011.2025.05.11

[14] Nordin, M., Persson, I., & Rooth, D.-O. (2010). Education–occupation mismatch: Is there an income penalty? Economics of Education Review, 29(6), 1047–1059. https://doi.org/10.1016/j.econedurev.2010.05.005

[15] Pominova, M., & Gabe, T. (2023). Population size and the job matching of college graduates. Applied Economics Letters, 30(20), 2994–2997. https://doi.org/10.1080/13504851.2022.2117774

[16] Robst, J. (2007). Education and job match: The relatedness of college major and work. Economics of Education Re-

view, 26(4), 397–407. https://doi.org/10.1016/j.econedurev.2006.08.003
[17] Salton, G., Wong, A., & Yang, C. S. (1975). A vector space model for automatic indexing. Communications of the ACM, 18(11), 613–620. https://doi.org/10.1145/361219.361220
[18] Saltelli, A., Ratto, M., Andres, T., Campolongo, F., Cariboni, J., Gatelli, D., Saisana, M., & Tarantola, S. (2008). Global sensitivity analysis: The primer. John Wiley & Sons. https://doi.org/10.1002/9780470725184
[19] Tian, X. (2018). The dynamic adjustment of disciplines and majors in colleges and universities: Models, problems, and integration improvement. Journal of Higher Education Management, 12(6), 44–50. https://doi.org/10.13316/j.cnki.jhem.20181109.001
[20] UNESCO Institute for Statistics. (2014). ISCED fields of education and training 2013 (ISCED-F 2013): Manual to accompany the International Standard Classification of Education 2011.
[21] United Nations. (2008). International standard industrial classification of all economic activities (ISIC), Rev. 4 (Statistical Papers, Series M, No. 4/Rev. 4).
[22] Wu, Z., & Guo, H. (2025). The current state, practical logic, and optimisation pathways of undergraduate programme-structure adjustment in China: An analysis of university programme-adjustment actions from 2014 to 2024. Journal of Higher Education Management, 19(2), 101–112. https://doi.org/10.13316/j.cnki.jhem.20250122.009
[23] Xu, X., & Wang, Z. (2021). An empirical study of coordination between professional master's degrees and industrial structure. Journal of Graduate Education, (6), 68–76. https://doi.org/10.19834/j.cnki.yjsjy2011.2021.06.10
[24] Xue, X., & Zhao, Y. (2022). Coordinated development of higher education structure and industrial structure in the Beijing–Tianjin–Hebei region: An empirical analysis based on panel data from 2008 to 2017. Journal of Changsha University of Science and Technology (Social Science Edition), 37(1), 74–84.
[25] Yang, S. (2022). Dynamic coupling mechanisms between undergraduate programme adjustment and industrial-structure evolution. Changsha: Hunan Science & Technology Press .
[26] Yang, S., & Wang, L. (2022). Coordinated development of undergraduate programme adjustment and industrial-structure evolution under high-quality development: Evidence from Hunan Province. University Education Science, (2), 64–74.
[27] Yang, S., Wang, M., & Wang, L. (2022). Undergraduate programme adjustment, industrial-structure evolution, and regional economic growth. Education & Economy, 38(6), 12–23.
[28] Yang, Y., & Song, D. (2016). Current conditions and future aspirations: Field-of-study matching among university graduates — A review of CNKI literature from the previous fifteen years. Journal of Higher Education Research, 39(4), 20–26.
[29] Zhang, W. (2023). The achievements and paths of building a leading country in higher education: The evolution from connotative development to high-quality development. China Higher Education Research, 39(10), 1–8. https://doi.org/10.16298/j.cnki.1004-3667.2023.10.01