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Regional Disparities and Coordinated Development of Talent Service Systems in China: A Sustainability Perspective

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Abstract

Regional talent service systems play an important role in supporting human capital development and sustainable regional development. However, improvements in overall talent service development may coexist with persistent spatial disparities and imbalances among service supply, demand, and environment. This study evaluates regional talent service systems across 30 provincial-level regions in China from 2015 to 2023 using the entropy weight–TOPSIS method, Dagum Gini coefficient decomposition, and coupling coordination model, supplemented by the coefficient of variation (CV). The results show that the national average development score increased from 0.179 to 0.325, while the overall Gini coefficient declined from 0.276 to 0.147. Nevertheless, between-region disparities remained the dominant source of inequality. The national coupling coordination degree increased from 0.373 to 0.553, accompanied by a decline in the average CV from 0.487 to 0.432. However, the northeastern region experienced an increase in CV despite improved coupling coordination, indicating that higher coordination indices do not necessarily imply greater subsystem balance. These findings highlight the importance of jointly assessing development levels, spatial disparities, and subsystem balance to inform sustainable regional talent service development.

Keywords: talent service; sustainable regional development; regional disparities; human capital; coupling coordination

1. Introduction

Human capital is an important resource for regional innovation and long-term economic development [1]. However, its contribution to sustainable regional development depends not only on the availability of talent but also on the conditions supporting talent development, allocation, and retention. Talent services provide institutional and organizational support for these processes by facilitating employment matching, career development, human resource allocation, and connections between talent and economic activities [2,3]. Unlike talent competitiveness, which primarily concerns the scale, quality, and competitive advantages of talent resources, regional talent service focuses on the service provision capacity, potential service demand, and supporting conditions that facilitate talent-related activities. Regional talent service can therefore be understood as a multidimensional human-capital support system embedded in broader regional economic and social development.

From a talent ecosystem perspective, regional talent service development involves multiple interrelated dimensions rather than the expansion of service provision alone.

Check for updates

Academic Editor: Jianming Cai

Received: 22 September 2026
Revised: 18 October 2026
Accepted: 30 October 2026
Published: 3 November 2026

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Specifically, talent service supply reflects the organizational, infrastructural, and resource foundations supporting service provision; talent service demand captures the potential needs arising from individual employment and career development as well as organizational recruitment and innovation activities; and talent service environment encompasses the broader socioeconomic conditions supporting the operation and development of talent services. These dimensions are analytically distinct but functionally related. For example, the expansion of service infrastructure may not be accompanied by corresponding increases in potential demand, while favorable employment and innovation opportunities may coexist with limitations in service provision or supporting environments. Previous research has also highlighted the relevance of regional attractiveness, public services, and quality-of-life conditions to talent mobility and location choices [4]. Accordingly, evaluating regional talent service development requires attention not only to its overall development level but also to the relative development of its constituent dimensions. Such an assessment is relevant to sustainable regional development because it considers the broader conditions under which human capital can be developed and utilized.

China provides a relevant context for examining regional talent service systems because its economic transformation and industrial development have been accompanied by substantial geographical differences in economic resources, innovation capacity, public services, and talent-related opportunities [5]. Previous studies have documented spatial disparities in talent competitiveness and talent-related development across Chinese regions [6,7]. These differences suggest that the foundations supporting talent services may also vary considerably across provinces. Although regional talent-related development may improve over time, such improvements do not necessarily occur at similar rates across geographical regions or among different dimensions of regional talent service systems. Consequently, an increase in the overall development level may coexist with persistent spatial inequality or uneven development among service supply, demand, and environment. Understanding these patterns is important for identifying the characteristics of regional talent service development and informing differentiated policy priorities.

Existing research has provided valuable insights into talent competitiveness, regional talent environments, and human resource service development [8–10]. Studies of regional talent service systems have also proposed multidimensional evaluation frameworks incorporating service resources, service activities, demand, and environmental conditions. Nevertheless, several issues warrant further investigation. First, although previous studies have examined different aspects of talent-related development, longitudinal and cross-provincial evidence on regional talent service systems remains limited. In particular, regional talent service differs conceptually from both talent competitiveness and the development of the human resource service industry, making it necessary to assess the broader conditions supporting talent-related service provision and potential demand. Second, existing regional evaluations have examined development levels and geographical differences, but further attention is needed to the structural sources of inequality in regional talent service development and their evolution over time. Third, although multidimensional evaluation and coupling coordination approaches have been applied in related research, changes in composite coordination indices do not necessarily indicate improvements in the relative balance among constituent dimensions. Distinguishing overall subsystem development from relative subsystem balance is therefore important for interpreting the multidimensional evolution of regional talent service systems. Addressing these issues can provide a more differentiated understanding of regional talent service development and its implications for sustainable regional development.

To address these issues, this study develops an integrated analytical framework comprising talent service supply, talent service demand, and talent service environment. Using

panel data from 30 provincial-level regions in mainland China covering 2015–2023, the study addresses three research questions: (1) How has the overall development level of regional talent service systems evolved across provinces and regions? (2) How have regional disparities changed over time, and what are their principal structural sources? (3) How have the supply, demand, and environment subsystems developed in terms of composite coordination and relative balance, and how do these patterns differ across regions? The entropy weight–TOPSIS method is employed to construct comparable development indices, while the Dagum Gini coefficient and its decomposition are used to examine regional disparities and their sources. The coupling coordination model is then applied to assess the composite coordination characteristics of the three subsystems, complemented by the coefficient of variation (CV) to examine changes in their relative dispersion. Alternative weighting schemes are further employed to assess the robustness of the principal findings.

This study contributes to the literature in three respects. First, building on previous research on talent competitiveness, human resource services, and regional talent service evaluation, it adopts an integrated supply–demand–environment framework to examine regional talent service as a multidimensional human-capital support system. Second, it provides longitudinal and cross-provincial evidence on the evolution of regional talent service development and the structural sources of spatial disparities, distinguishing overall improvements from changes in geographical inequality. Third, by combining coupling coordination analysis with a supplementary assessment of subsystem balance, it distinguishes improvements in composite coordination indices from changes in relative differences among subsystem development levels. This distinction provides a more cautious interpretation of coordinated development and highlights the limitations of relying exclusively on aggregate indices. Overall, the study offers an integrated assessment of regional talent service development that considers overall development levels, spatial disparities, and internal structural balance, thereby providing evidence relevant to discussions of sustainable regional development.

2. Literature Review

Existing research on talent services has examined the organization, provision, and evaluation of services supporting talent development and allocation. Bao and Qiu [11] discussed the institutional arrangements and supporting resources involved in regional service systems for scientific and technological talent. Moving from system construction to evaluation, Sun [12] proposed a regional talent service evaluation framework encompassing talent resources, service activities, service institutions, and environmental conditions. Dong et al. [13] further developed a multidimensional evaluation framework for a high-quality talent service system in Hubei Province, incorporating service supply, demand, inputs, outputs, and environment. These studies indicate that regional talent service systems are complex and multidimensional, involving various service providers, service activities, and supporting conditions. Their development levels therefore require a comprehensive assessment across multiple dimensions.

The supply and demand of talent-related services constitute important aspects of regional talent service development. On the supply side, professional service organizations and intermediary institutions facilitate connections among workers, employers, and other relevant actors. Benner [14] examined how labor market intermediaries contribute to regional labor market adjustment through transaction-cost reduction, network building, and risk management. Giloth [15] highlighted the role of workforce and education intermediaries in connecting employers, educational institutions, and workers and addressing fragmentation in workforce development systems. On the demand side, talent services respond to the differentiated needs of individuals and organizations. Chen [16] identified

work-related, living, and supplementary needs in an indicator system for talent service demand. Beyond individual needs, organizational activities such as recruitment, talent allocation, and research and innovation may also generate demand for talent-related services. Taken together, these studies suggest that regional talent service development involves both the capacity to provide services and the diverse needs arising from talent development and organizational activities.

The development of regional talent service systems is closely related to the broader regional environment in which they operate. Existing studies have examined the external conditions for talent development from different perspectives. Li and Tang [9] developed an evaluation framework for urban talent environments and assessed 15 emerging first-tier cities in China. He and Dun [8] investigated how configurations of innovation, economic, living, ecological, and social environments are associated with urban innovative talent agglomeration. Related research has further examined the relationships between regional conditions and talent mobility or location choices. Cui et al. [17] found that employment opportunities and urban amenities were associated with the interregional migration of graduates from China's "first-class" universities, while He et al. [18] examined the relationship between urban amenities and the location choices of excellent returning scientists. In addition, Hao et al. [19] investigated the relationships among urban amenities, highly skilled talent, high-technology enterprises, and innovation. Overall, these studies indicate that economic conditions, public services, and living environments constitute important external conditions for talent development and mobility. Although they do not directly examine talent service systems, their findings provide useful insights into the broader environment in which regional talent services develop.

A related body of literature has developed quantitative approaches to evaluating talent-related development and regional differences. Studies of innovative talent competitiveness and scientific and technological talent competitiveness have constructed multidimensional evaluation systems and examined regional development patterns in China [7,20]. At the international level, the Global Talent Competitiveness Index 2025 [21] assesses countries' capabilities to enable, attract, grow, and retain talent, together with talent-related skills. Other research has investigated the relationship between human capital quality and regional economic growth [22]. More closely related to the service sector, Li and Li [10] evaluated the high-quality development of China's human resource service industry using a multidimensional framework and methods including entropy-weighted TOPSIS and coupling coordination analysis.

Despite these contributions, several issues warrant further investigation. First, although existing studies have evaluated various aspects of talent-related development, further attention to regional talent service systems is warranted. Unlike research on talent competitiveness, which primarily focuses on the scale, quality, and competitive advantages of talent resources, or studies of the human resource service industry, which emphasize the development of the service sector itself, regional talent service systems are characterized by their service orientation and multidimensional nature. They encompass the foundations of talent-related service provision, respond to the diverse needs of individuals and employing organizations, and operate within broader regional socioeconomic environments. Although previous studies have explored the components and evaluation dimensions of talent service systems, further research is needed to assess their development levels and dynamic changes across regions while taking these distinctive characteristics into account. Second, previous research has examined service provision, service needs, and regional talent environments, providing important insights into different aspects of talent service development. While these dimensions have also been incorporated into existing talent service evaluation frameworks, their relative development and coordination across regions

and over time remain worthy of further examination. Third, although regional differences in talent-related development have been widely studied, a more integrated assessment of regional talent service systems could provide additional insights into the sources of disparities and their relationship with multidimensional development patterns.

Building on this literature, the present study adopts an analytical framework informed by the talent ecosystem perspective and supply–demand considerations to evaluate the development level of regional talent service systems in China. Using data from 30 provinces over the period 2015–2023, the study integrates composite development-level assessment, Dagum Gini coefficient decomposition, and coupling coordination analysis within a supply–demand–environment framework. This approach extends existing regional talent service evaluation research by providing longitudinal and cross-provincial evidence on overall development patterns, the composition of regional disparities, and the relative coordination among the three dimensions. The coupling coordination results are interpreted as descriptive measures of multidimensional development and balance rather than evidence of causal interactions among the subsystems.

3. Index System Construction

Talent ecosystem theory provides a systems-based perspective for understanding talent development and its relationship with the surrounding environment. Ecological systems theory emphasizes that individual development takes place within multiple layers of environmental influences [23]. Extending this perspective to talent research, existing studies have examined the dynamic development of human resources within organizations, as well as the relationships among talent resources, institutions, and broader socioeconomic environments [24–26]. From an ecosystem perspective, talent development is not determined solely by individual capabilities or the availability of talent resources. It also depends on the organizational and institutional arrangements through which resources are mobilized and the environmental conditions under which talent-related activities take place. This perspective highlights the importance of examining the various elements that support talent development and their relationships within a broader regional system.

Within this broader system, talent services play a supporting role in talent development and allocation. They connect talent-related resources with the needs of individuals and organizations through activities such as recruitment, employment support, career development, and talent allocation. The provision of these services relies on service organizations, platforms, and relevant public support, while their development is also associated with the needs arising from individual and organizational activities. Moreover, talent services operate within regional socioeconomic environments that shape the availability of resources and the conditions for service provision. Understanding regional talent service development therefore requires attention to three aspects: the foundations supporting service provision, the potential needs for talent-related services, and the external conditions under which these services operate. Building on this reasoning and previous research on regional talent service evaluation [12,13], this study constructs an analytical framework comprising talent service supply, talent service demand, and talent service environment.

3.1. Talent Service Supply

Talent service supply reflects the foundations supporting the provision of talent-related services within a region. In China's human resource service system, market-oriented professional services and public employment services jointly support talent development and allocation [2]. Accordingly, this study evaluates talent service supply from two dimensions: professional service supply and public service supply.

Professional service supply reflects the organizational and platform foundations of specialized talent-related services. Human resource service enterprises provide recruitment, training, employment support, and human resource allocation services, serving as important providers of market-oriented talent services. Existing research has examined the regional development of human resource service enterprises using enterprise registration data [27]. Accordingly, this study selects the relative scale of newly registered human resource service enterprises to characterize the development of professional service providers. Ideally, the number of operating human resource service institutions would provide a more direct measure of their scale. However, inconsistent provincial data disclosure makes it difficult to construct a continuous and comparable panel for 2015–2023. The selected indicator therefore serves as a proxy for the relative scale of newly established service providers. In addition, human resource service industrial parks facilitate the concentration of service organizations and related resources, providing specialized platforms for service provision. Consistent with previous research [3], this study adopts the scale of human resource service industrial parks to characterize the development of professional service platforms.

Public service supply reflects government support for employment and related public services. Public employment services constitute an important component of China's human resource service system, providing employment assistance and other basic services [2]. As fiscal expenditure provides essential financial support for public service provision, this study selects the share of social security and employment expenditure to reflect the relative level of government fiscal support for employment and related public services.

3.2. Talent Service Demand

Talent service demand reflects the potential need for talent-related services arising from individual employment and career development activities, as well as organizational recruitment and workforce development activities. Existing research has identified employment, training, and career development as important components of talent service demand [16] and has considered individuals and enterprises as sources of potential demand in the regional development of the human resource service industry [27]. Accordingly, this study evaluates talent service demand from two dimensions: individual-level potential service demand and organizational-level potential service demand.

Individual-level potential service demand reflects the potential need for talent-related services arising from employment and career development activities. University graduates constitute an important group entering the labor market, generating potential demand for job placement, employment guidance, and career development services. Considering the differences in educational attainment and employment characteristics, this study selects the relative scale of undergraduate graduates and the relative scale of postgraduate graduates to characterize potential service demand among university graduates. Meanwhile, employed individuals may require professional services related to job mobility, skills training, and career advancement. Therefore, the relative scale of urban unit employees is included to reflect potential service demand among the employed population. These indicators are consistent with previous research that considered university graduates and employed populations when examining demand-side factors associated with the regional development of human resource service enterprises [27].

Organizational-level potential service demand reflects the potential need for talent-related services arising from organizational operations and innovation activities. Enterprises constitute major demand-side participants in the human resource service market, requiring services related to recruitment, talent allocation, and workforce development [27]. Accordingly, this study selects the relative scale of corporate legal entities to characterize the organizational base of potential service demand. Moreover, technological upgrading

and the development of knowledge-intensive industries increase the importance of specialized skills and innovative talent [28]. The share of high-tech enterprises is therefore included to reflect potential demand for specialized talent-related services associated with technology-intensive business activities. In addition, research and innovation activities in higher education institutions depend on the participation and development of researchers and other specialized personnel [29]. Accordingly, this study selects the relative scale of university R&D projects to characterize potential service demand associated with research activities.

3.3. Talent Service Environment

Talent service environment reflects the external conditions that support the operation and development of regional talent service systems. From a talent ecosystem perspective, talent-related activities are embedded in broader socioeconomic environments in which organizations, resources, and supporting facilities interact [30]. Previous research on regional talent attractiveness has also highlighted the relevance of economic opportunities, educational resources, public services, infrastructure, and ecological conditions [31,32]. Accordingly, this study evaluates talent service environment from six dimensions: economic environment, digital infrastructure, educational resources, healthcare conditions, transportation conditions, and ecological environment.

Economic environment reflects the regional economic conditions supporting talent service development. Economic development provides a foundation for business activities and resource allocation, while external economic connections form part of the broader market environment in which human resource service enterprises operate. Previous research has incorporated regional economic development and openness into analyses of the spatial distribution of human resource service enterprises [27]. Accordingly, this study selects economic development level and openness level to characterize the regional economic environment.

Digital infrastructure reflects the information connectivity available to support talent-related activities and service provision. Previous research has highlighted the relevance of regional internet development to the spatial distribution of human resource service enterprises [27], while broadband access has also been incorporated into assessments of urban talent attractiveness [32]. Accordingly, this study selects the relative scale of broadband access subscribers to characterize regional digital infrastructure.

Educational resources provide an institutional foundation for talent cultivation and knowledge development. Universities are important participants in regional talent ecosystems [30], and the availability of higher education institutions has been incorporated into evaluations of urban talent attractiveness [32]. Accordingly, the scale of higher education resources is selected to reflect regional higher education capacity.

Healthcare conditions represent an important component of the public service environment. Previous research has identified medical resources as a relevant factor in the location choices of highly educated individuals [33]. This study therefore adopts the number of beds in healthcare institutions to characterize regional healthcare capacity.

Transportation conditions reflect the physical infrastructure supporting mobility and access to regional activities. Previous research has highlighted the relevance of transportation accessibility and environmental quality to urban livability and attractiveness [34]. Following existing assessments of urban talent attractiveness [35], this study selects per capita urban road area to characterize regional transportation conditions.

Ecological environment reflects the environmental quality of the region in which talent-related activities take place. Previous research has examined the relationship between air pollution and the employment location choices of highly educated graduates [35], while air quality has also been incorporated into multidimensional assessments of urban talent

attractiveness [32]. Accordingly, this study selects days with good air quality to characterize regional ecological conditions. Together, these six dimensions capture the broader external conditions within which regional talent service systems operate and develop.

Based on the preceding analysis, this study constructs a regional talent service evaluation index system comprising three first-level dimensions, 10 second-level dimensions, and 16 third-level indicators. The system captures the foundations of talent service provision, the conditions generating potential service demand, and the external environment supporting talent service development. The complete index system is presented in Table 1, while the measurement and data sources of individual indicators are provided in Appendix A (Table A1).

Table 1. Evaluation index system for regional talent service.

First-Level Dimensions	Second-Level Dimensions	Third-Level Indicators
Talent Service Supply	Professional Service Supply	Relative scale of newly registered human resource service enterprises
		Scale of human resource service industrial parks
	Public Service Supply	Share of social security and employment expenditure
Talent Service Demand	Individual-level Potential Service Demand	Relative scale of undergraduate graduates
		Relative scale of postgraduate graduates
		Relative scale of urban unit employees
	Organizational-level Potential Service Demand	Relative scale of corporate legal entities
		Share of high-tech enterprises
		Relative scale of university R&D projects
Talent Service Environment	Economic Environment	Economic development level
		Openness level
	Digital Infrastructure	Relative scale of broadband access subscribers
	Educational Resources	Scale of higher education resources
	Healthcare Conditions	Number of beds in healthcare institutions
	Transportation Conditions	Per capita urban road area
	Ecological Environment	Days with good air quality

4. Methods and Data

4.1. Methods

4.1.1. Entropy Weight-TOPSIS Model

The entropy weight–TOPSIS method combines an objective, information-based weighting procedure with a distance-to-ideal-solution approach. The entropy weight method determines indicator weights based on their variation across observations, while TOPSIS evaluates each observation according to its relative distance from the positive and negative ideal solutions. This combined approach is employed to construct a composite index measuring the development level of regional talent service systems.

To ensure comparability across provinces and years, this study adopts a pooled-sample approach. Specifically, the data for 30 provincial-level regions from 2015 to 2023 are combined into a single dataset comprising 270 province-year observations. Indicator normal-

ization, entropy weight calculation, and the determination of positive and negative ideal solutions are conducted using the pooled dataset. Consequently, a common set of indicator weights and evaluation benchmarks is applied throughout the study period.

Because the 16 indicators have different measurement units, min–max normalization is applied to eliminate differences in scale. All indicators in the evaluation system are positively oriented. The normalized value is calculated as follows:

$$z_{ij} = \frac{x_{ij} - min(x_j)}{max(x_j) - min(x_j)}, \tag{1}$$

where x_{ij} represents the original value of indicator j for observation i, and z_{ij} denotes its normalized value. The minimum and maximum values are determined from all 270 observations.

The proportion of observation i for indicator j is calculated as:

$$p_{ij} = \frac{z_{ij}}{\sum_i^n z_{ij}}, \tag{2}$$

The information entropy of indicator j is calculated as:

$$e = -\frac{1}{\ln n} P_{ij} \ln P_{ij}, \tag{3}$$

where $n = 270$ is the total number of province-year observations. When $P_{ij} = 0$, the term P_{ij} $\ln P_{ij}$ is defined as zero.

The entropy weight of indicator j is then determined by:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^m (1 - e_j)}, \tag{4}$$

where $m = 16$ is the number of indicators and w_j represents the weight assigned to indicator j. The resulting weights remain constant across provinces and years. The resulting entropy weights for all 16 indicators are reported in Appendix A (Table A2).

The weighted normalized value is calculated as:

$$v_{ij} = w_j z_{ij}, \tag{5}$$

The positive and negative ideal solutions are determined as:

$$V_j^+ = \max\left\{v_{1j}, v_{2j}, \ldots, v_{nj}\right\}, \tag{6}$$

$$V_j^- = \min\left\{v_{1j}, v_{2j}, \ldots, v_{nj}\right\}, \tag{7}$$

Both ideal solutions are determined using the pooled sample of 270 observations. The Euclidean distances between each observation and the positive and negative ideal solutions are calculated as:

$$D_i^+ = \sqrt{\sum_{j=1}^m \left(V_j^+ - v_{ij}\right)^2}, \tag{8}$$

$$D_i^- = \sqrt{\sum_{j=1}^m \left(V_j^- - v_{ij}\right)^2}, \tag{9}$$

Finally, the composite development score of the regional talent service system is calculated as follows:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-}, \tag{10}$$

where $S_i \in [0, 1]$. A higher value indicates a higher development level of the regional talent service system relative to the common evaluation benchmarks. The entropy weights reflect the statistical variation of indicators within the pooled sample rather than their causal effects or intrinsic importance.

4.1.2. Dagum Gini Coefficient and Decomposition

The Dagum Gini coefficient is employed to measure regional disparities in the development level of talent service systems and identify their sources. Compared with conventional inequality measures, this method accounts for overlapping distributions among regions and decomposes overall disparities into within-region disparities, net between-region disparities, and transvariation. Following Dagum [36], the overall Gini coefficient is calculated as follows:

$$G = \frac{\sum_{j=1}^{k}\sum_{h=1}^{k}\sum_{i=1}^{N_j}\sum_{r=1}^{N_h}\left|S_{ji} - S_{hr}\right|}{2N^2\overline{S}}, \tag{11}$$

where G denotes the overall Gini coefficient, $k = 4$ represents the number of regions, and $N = 30$ is the total number of provincial-level regions. The subscripts j and h denote regions, while N_j and N_h represent the numbers of provinces in regions j and h, respectively. S_{ji} and S_{hr} represent the composite development scores of the regional talent service systems in provinces i and r of regions j and h, respectively, as calculated in Section 4.1.1. $\overline{S}$ denotes the national mean composite development score for a given year.

The overall Gini coefficient is further decomposed into within-region disparities (G_w), net between-region disparities (G_{nb}), and transvariation (G_t):

$$G = G_w + G_{nb} + G_t, \tag{12}$$

The within-region component is calculated as:

$$G_{jj} = \frac{\sum_{i=1}^{N_j}\sum_{r=1}^{N_j}\left|S_{ji} - S_{jr}\right|}{2N_j^2\overline{S_j}}, \tag{13}$$

$$G_{jh} = \frac{\sum_{i=1}^{N_j}\sum_{r=1}^{N_h}\left|S_{ji} - S_{hr}\right|}{N_j n N_h\left(\overline{S_j} + \overline{S_h}\right)}, \tag{14}$$

where G_{jj} denotes the Gini coefficient within region j, and G_{jh} denotes the Gini coefficient between regions j and h. $\overline{S_j}$ and $\overline{S_h}$ represent the mean composite development scores of regions j and h, respectively.

The contributions of within-region disparities, net between-region disparities, and transvariation are calculated as follows:

$$G_w = \sum_{j=1}^{k} G_{jj} p_j s_j, \tag{15}$$

$$G_{nb} = \sum_{j=2}^{k}\sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j) D_{jh}, \tag{16}$$

$$G_t = \sum_{j=2}^{k}\sum_{h=1}^{j-1} G_{jh}(p_j s_h + p_h s_j)\,(1 - D_{jh}), \tag{17}$$

where $p_j = N_j/N$ denotes the proportion of provinces in region j, and $s_j = N_j\overline{S_j}/\left(N\overline{S}\right)$ represents the share of region j in the total composite development scores. Similarly, $p_h = N_h/N$ and $s_h = N_h\overline{S_h}/\left(N\overline{S}\right)$. D_{jh} is an auxiliary coefficient used to distinguish net between-region disparities from transvariation, defined as $D_{jh} = \left|\overline{S_j} - S_h\right|/\left[G_{jh}\left(\left(\overline{S_j} + \overline{S_h}\right)\right)\right]$ when the denominator is positive. The contribution rates of the three components are calculated as G_w/G, G_{nb}/G, and G_t/G, respectively.

In this study, the 30 provinces are classified into four geographical regions: eastern, northeastern, central, and western China. The Dagum Gini coefficient and its decomposition are calculated separately for each year from 2015 to 2023 to examine the temporal evolution of regional disparities in the development level of talent service systems and their sources.

4.1.3. Coupling Coordination Model

The coupling coordination model is employed to assess the coordinated development of the three subsystems of regional talent service systems: talent service supply, talent service demand, and talent service environment. The model combines the coupling degree, which measures the relative balance among subsystem development levels, with a comprehensive development index. The composite development scores of the three subsystems are calculated separately using the entropy weight–TOPSIS method described in Section 4.1.1 and are directly used in the coupling coordination model without additional normalization. Following previous studies [37], the coupling degree is calculated as follows:

$$C = 3 \times \frac{\sqrt[3]{U_1 U_2 U_3}}{\sum_{i=1}^{3} U_i}, \tag{18}$$

where C denotes the coupling degree, and U_1, U_2, and U_3 represent the composite development scores of the talent service supply, talent service demand, and talent service environment subsystems, respectively. A higher value of C indicates greater relative balance among the three subsystems.

The comprehensive development index is calculated as follows:

$$T = \alpha U_1 + \beta U_2 + \gamma U_3, \tag{19}$$

where T denotes the comprehensive development index, and α, β, and γ represent the weights assigned to the three subsystems. Equal weights are assigned $\alpha = \beta = \gamma = 1/3$ to reflect the equal standing of supply, demand, and environment in the coordination assessment. These weights differ from the entropy-derived indicator weights used in the composite evaluation, as they reflect an analytical assumption rather than the statistical variation of indicators.

The coupling coordination degree is calculated as follows:

$$D = \sqrt{C \times T}, \tag{20}$$

where D denotes the coupling coordination degree, integrating the coupling degree C and the comprehensive development index T. A higher value of D indicates a higher level of model-based coordinated development. However, an increase in D may result from improvements in overall subsystem development levels, greater relative balance among subsystems, or both. Therefore, the coupling degree and subsystem development scores are also examined to distinguish these changes. The model provides a descriptive assessment of coordination and does not establish causal interactions among the three subsystems.

To complement the coupling coordination analysis, this study further employs the coefficient of variation (CV) to assess the relative balance among the three talent service subsystems. Although the coupling coordination degree (D) reflects the combined characteristics of subsystem development and coupling, it does not independently measure the dispersion of subsystem development scores. Therefore, CV is introduced as a supplementary descriptive indicator to examine whether changes in coupling coordination are accompanied by changes in the relative differences among the supply, demand, and environment subsystems. The CV is calculated as follows:

$$CV_{it} = \frac{\sqrt{\frac{1}{3}\sum_{k=1}^{3}\left(S_{kit} - \overline{S_{it}}\right)^2}}{\overline{S_{it}}}, \tag{21}$$

where S_{kit} denotes the development score of subsystem k in province i and year t, with $k = 1, 2, 3$ representing the supply, demand, and environment subsystems, respectively. $\overline{S_{it}} = (S_{1it} + S_{2it} + S_{3it})/3$ represents the mean development score of the three subsystems.

A lower *CV* indicates smaller relative differences among subsystem scores, whereas a higher *CV* indicates greater relative disparities. The *CV* is first calculated for each province-year observation and then averaged across provinces to obtain the corresponding regional and national values. Unlike the coupling coordination degree, *CV* focuses exclusively on the relative dispersion of subsystem scores and is therefore used as a complementary measure rather than a substitute for the coupling coordination model.

4.2. Data

This study uses panel data from 30 provincial-level regions in mainland China covering the period 2015–2023 (see in Supplementary Materials). Tibet, Hong Kong, Macao, and Taiwan were excluded due to missing data. For regional comparisons, the 30 provincial-level regions were grouped into four geographical regions—Eastern, Central, Western, and Northeastern China—following the four-region classification commonly used by the National Bureau of Statistics of China. The eastern region comprises Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the central region comprises Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; the western region comprises Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang; and the northeastern region comprises Liaoning, Jilin, and Heilongjiang. The data were primarily obtained from the National Bureau of Statistics of China, provincial education statistics published by the Ministry of Education of China, the EPS Data Platform, and Qichacha. The dataset comprises 16 indicators covering three subsystems: talent service supply, talent service demand, and talent service environment. Detailed indicator definitions, measurement methods, and data sources are provided in Appendix A (Table A1).

For the talent service supply subsystem, data on newly established human resource service enterprises were retrieved from Qichacha on 10 October 2026. Using "human resource services" as the business-scope search keyword, enterprises were identified by their registered province and establishment date. The number of newly established enterprises was calculated for each province and year from 2015 to 2023, regardless of their registration status at the time of data extraction, to capture annual market entry. Data on human resource service industrial parks were collected from publicly available information through province-by-province searches. Based on their locations and establishment dates, the cumulative number of parks established by the end of each year was calculated for each province. A logarithmic transformation, $\ln(1 + x)$, was applied to the park counts to reduce differences in magnitude across provinces. Other supply-related indicators were obtained from official statistical sources.

For the talent service demand subsystem, data on undergraduate and postgraduate graduates were obtained from provincial education statistics published by the Ministry of Education of China. Data on high-tech enterprises and university R&D projects were obtained from the EPS Data Platform, while data on urban unit employees and corporate legal entities were obtained from the National Bureau of Statistics of China. These indicators were converted into relative measures using the corresponding population or corporate legal-entity denominators.

For the talent service environment subsystem, data on economic development, economic openness, broadband internet subscribers, higher education institutions, healthcare beds, and urban road area were obtained from official statistical sources. Data on days with good air quality were retrieved from the China Macroeconomic Database of the EPS Data Platform. All indicators were calculated according to their respective operational definitions.

To maintain data consistency across provinces and years, uniform indicator definitions and calculation procedures were applied throughout the study period. Missing observations

in the air quality indicator for 2018 and 2021 were estimated using linear interpolation based on data from adjacent years. The resulting balanced panel comprised 270 province-year observations. As illustrated in Figure 1, the entropy weight–TOPSIS method was used to calculate the overall development level of regional talent service systems and the composite scores of the three subsystems. Based on these results, the Dagum Gini coefficient was employed to examine regional disparities and their sources, while the coupling coordination model was applied to assess coordination among talent service supply, demand, and environment.

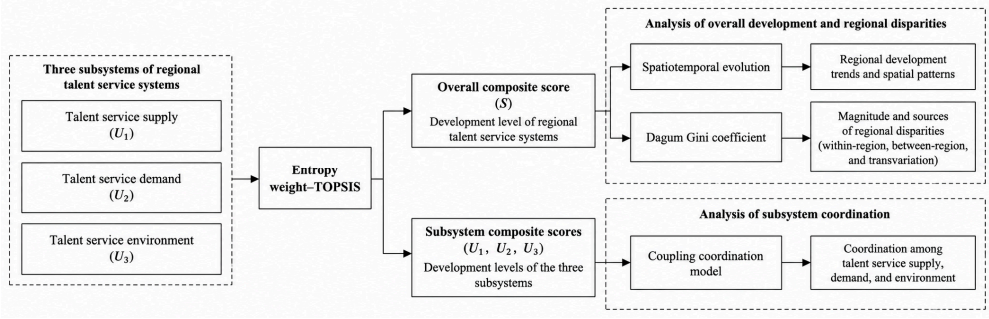


Figure 1. Analytical framework of the study.

5. Empirical Results and Analysis

5.1. Development Levels of Regional Talent Service Systems

Using the entropy weight–TOPSIS method, this study calculated the composite development scores of regional talent service systems across 30 provincial-level regions in China from 2015 to 2023, as presented in Table 2. The national average score increased steadily from 0.179 in 2015 to 0.325 in 2023, corresponding to a compound annual growth rate (CAGR) of approximately 7.75%. This upward trend indicates an overall improvement in the measured development level of regional talent service systems during the study period.

At the provincial level, all 30 provincial-level regions recorded higher composite development scores in 2023 than in 2015, although the magnitude of improvement varied considerably. Beijing consistently maintained the highest score, increasing from 0.475 in 2015 to 0.625 in 2023. In 2023, Beijing (0.625), Shanghai (0.473), Guangdong (0.432), Jiangsu (0.423), and Zhejiang (0.401) recorded the highest development scores, while Qinghai (0.138), Xinjiang (0.184), and Ningxia (0.210) remained at the lower end of the distribution. Furthermore, 17 of the 30 provincial-level regions recorded scores below the national average of 0.325 in 2023, indicating persistent differences in measured development levels across provinces.

At the regional level, the eastern region consistently recorded the highest average development score, increasing from 0.270 in 2015 to 0.404 in 2023. The northeastern, central, and western regions also experienced improvements, with their average scores rising from 0.167 to 0.312, from 0.158 to 0.326, and from 0.112 to 0.256, respectively. In terms of growth, the western region recorded the highest CAGR (10.88%), followed by the central (9.47%), northeastern (8.13%), and eastern (5.17%) regions. Despite its relatively rapid growth, the western region remained the lowest-scoring region throughout the study period. Moreover, the central region surpassed the northeastern region in 2021, changing the regional ranking from eastern–northeastern–central–western in 2015 to eastern–central–northeastern–western in 2023.

Overall, the results indicate that the measured development level of regional talent service systems improved across China between 2015 and 2023, while differences across provinces and regions persisted. The eastern region maintained its leading position, whereas

the western and central regions exhibited relatively faster growth from lower initial levels. The magnitude and sources of regional disparities are further examined using the Dagum Gini coefficient in Section 5.2.

Table 2. Talent service levels across provincial-level regions in China, 2015–2023.

Area	Province	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average
Entire Country	Average	0.179	0.186	0.197	0.216	0.238	0.268	0.291	0.309	0.325	0.245
East Area	Beijing	0.475	0.475	0.489	0.508	0.554	0.564	0.585	0.610	0.625	0.543
	Tianjin	0.271	0.264	0.270	0.278	0.307	0.317	0.330	0.337	0.341	0.302
	Hebei	0.131	0.160	0.165	0.199	0.224	0.231	0.267	0.274	0.318	0.219
	Shanghai	0.378	0.375	0.385	0.393	0.412	0.424	0.461	0.462	0.473	0.418
	Jiangsu	0.320	0.314	0.318	0.357	0.381	0.390	0.404	0.410	0.423	0.369
	Zhejiang	0.265	0.282	0.302	0.327	0.331	0.356	0.366	0.387	0.401	0.335
	Fujian	0.181	0.184	0.190	0.222	0.225	0.251	0.282	0.318	0.343	0.244
	Shandong	0.261	0.273	0.300	0.345	0.352	0.364	0.377	0.383	0.392	0.339
	Guangdong	0.312	0.305	0.315	0.358	0.369	0.399	0.422	0.429	0.432	0.371
	Hainan	0.107	0.114	0.110	0.121	0.146	0.197	0.242	0.263	0.293	0.177
	Average	0.270	0.275	0.284	0.311	0.330	0.349	0.374	0.387	0.404	0.332
Northeast Area	Heilongjiang	0.137	0.135	0.138	0.150	0.161	0.194	0.206	0.259	0.269	0.183
	Liaoning	0.183	0.185	0.245	0.269	0.311	0.331	0.347	0.350	0.358	0.287
	Jilin	0.181	0.191	0.231	0.231	0.254	0.279	0.273	0.289	0.310	0.249
	Average	0.167	0.170	0.205	0.217	0.242	0.268	0.275	0.299	0.312	0.240
Central Area	Shanxi	0.101	0.109	0.116	0.121	0.129	0.141	0.230	0.252	0.272	0.163
	Anhui	0.158	0.187	0.177	0.186	0.241	0.251	0.300	0.341	0.360	0.245
	Jiangxi	0.169	0.168	0.186	0.241	0.286	0.282	0.309	0.314	0.317	0.252
	Henan	0.173	0.175	0.176	0.200	0.206	0.239	0.282	0.326	0.338	0.235
	Hubei	0.171	0.172	0.224	0.265	0.285	0.304	0.314	0.331	0.352	0.269
	Hunan	0.174	0.172	0.172	0.206	0.230	0.256	0.277	0.302	0.316	0.234
	Average	0.158	0.164	0.175	0.203	0.230	0.246	0.285	0.311	0.326	0.233
West Area	Inner Mongolia	0.100	0.105	0.107	0.111	0.119	0.156	0.198	0.246	0.279	0.158
	Guangxi	0.112	0.116	0.122	0.157	0.195	0.203	0.235	0.271	0.279	0.188
	Chongqing	0.152	0.156	0.156	0.167	0.178	0.216	0.227	0.232	0.239	0.191
	Sichuan	0.195	0.199	0.222	0.224	0.254	0.307	0.333	0.355	0.375	0.274
	Guizhou	0.078	0.101	0.104	0.114	0.148	0.232	0.253	0.271	0.274	0.175
	Yunnan	0.090	0.110	0.113	0.121	0.126	0.193	0.200	0.248	0.282	0.165
	Shaanxi	0.166	0.195	0.198	0.203	0.214	0.258	0.274	0.280	0.308	0.233
	Gansu	0.091	0.094	0.097	0.107	0.161	0.262	0.249	0.242	0.250	0.173
	Qinghai	0.072	0.077	0.080	0.091	0.104	0.110	0.123	0.126	0.138	0.102
	Ningxia	0.087	0.086	0.089	0.102	0.118	0.186	0.194	0.205	0.210	0.142
	Xinjiang	0.090	0.095	0.104	0.100	0.113	0.150	0.156	0.169	0.184	0.129
	Average	0.112	0.121	0.127	0.136	0.157	0.207	0.222	0.240	0.256	0.175

5.2. Regional Disparities and Their Sources in Talent Service System

5.2.1. Within-Region Disparities in Talent Service System

Figure 2 illustrates the evolution of within-region Gini coefficients across the four major regions of China from 2015 to 2023. Overall, within-region disparities exhibited different temporal patterns across regions. The eastern region recorded the highest within-region Gini coefficient from 2015 to 2022, although its coefficient declined substantially from 0.218 in 2015 to 0.118 in 2023. The western region also experienced a decline, from 0.179 to 0.129, but surpassed the eastern region to record the highest within-region coefficient in 2023. In the central region, the coefficient decreased from 0.073 to 0.049, reaching the lowest level among the four regions in 2023. By contrast, the northeastern region exhibited a more

fluctuating pattern, with its coefficient increasing from 0.061 in 2015 to a peak of 0.138 in 2019 before declining to 0.063 in 2023.

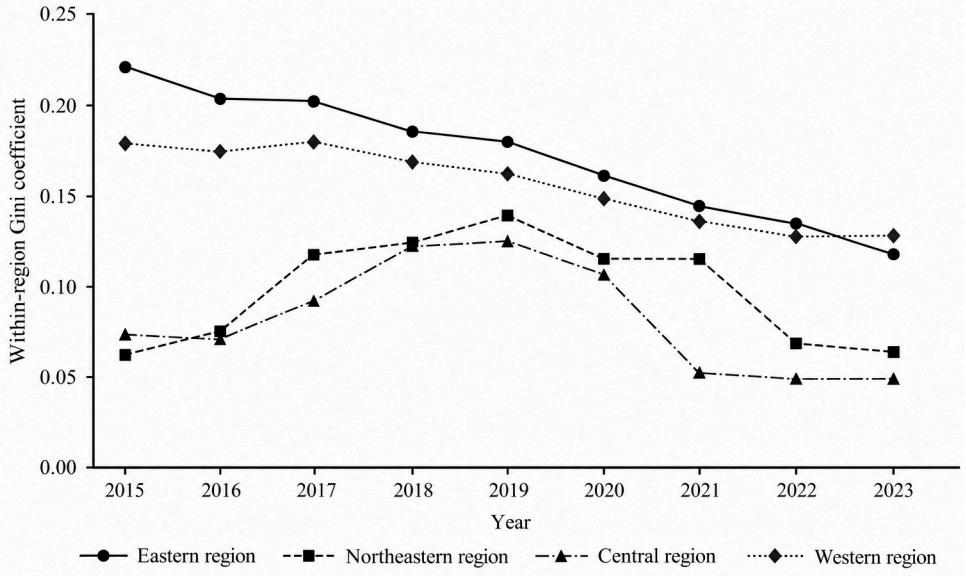


Figure 2. Evolution of within-region Gini coefficients across China's four major regions, 2015–2023.

Overall, the results indicate that within-region disparities narrowed in the eastern, central, and western regions over the study period, whereas the northeastern region experienced an initial widening followed by a subsequent decline. Despite the general reduction in within-region disparities, differences in their magnitude and evolution persisted across the four regions.

5.2.2. Between-Region Disparities in Talent Service System

Figure 3 presents the evolution of pairwise between-region Gini coefficients across China's four major regions from 2015 to 2023. Overall, the Gini coefficients declined across all six regional pairs, although the magnitude of reduction varied. The eastern–western pair consistently exhibited the largest disparity, with its Gini coefficient decreasing from 0.429 in 2015 to 0.230 in 2023, a reduction of approximately 46.4%. Despite this decline, the eastern–western coefficient remained considerably higher than those of the other regional pairs, indicating persistent differences in the distribution of talent service system development levels between the two regions.

Among the six regional pairs, the eastern–central disparity exhibited the largest proportional reduction, with its Gini coefficient declining from 0.302 in 2015 to 0.124 in 2023, a decrease of approximately 58.9%. The eastern–northeastern disparity also narrowed, with its coefficient falling from 0.280 to 0.142. Meanwhile, the northeastern–western, central–western, and northeastern–central coefficients decreased from 0.225 to 0.127, from 0.209 to 0.138, and from 0.084 to 0.062, respectively. Notably, the eastern–central coefficient, which was the second highest in 2015, had fallen below the eastern–northeastern, central–western, and northeastern–western coefficients by 2023. These changes indicate that the relative pattern of between-region disparities evolved alongside the overall narrowing of regional differences.

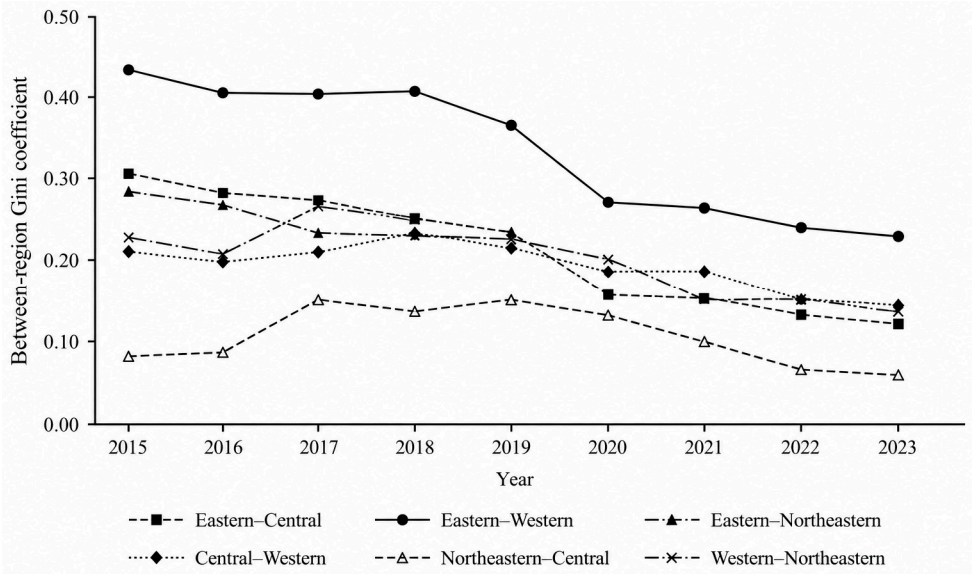


Figure 3. Evolution of between-region Gini coefficients across China's four major regions, 2015–2023.

5.2.3. Overall Disparities and Their Sources in Talent Service System

Figure 4 presents the evolution of the overall Dagum Gini coefficient and the decomposition of regional disparities in talent service system development from 2015 to 2023. The overall Gini coefficient declined from 0.276 in 2015 to 0.147 in 2023, representing a reduction of approximately 46.7%. Although a slight increase was observed in 2017, the overall trend was downward. The largest annual decline occurred between 2019 and 2020, when the coefficient decreased from 0.241 to 0.193. These results indicate a substantial narrowing of relative disparities in the measured development level of regional talent service systems during the study period.

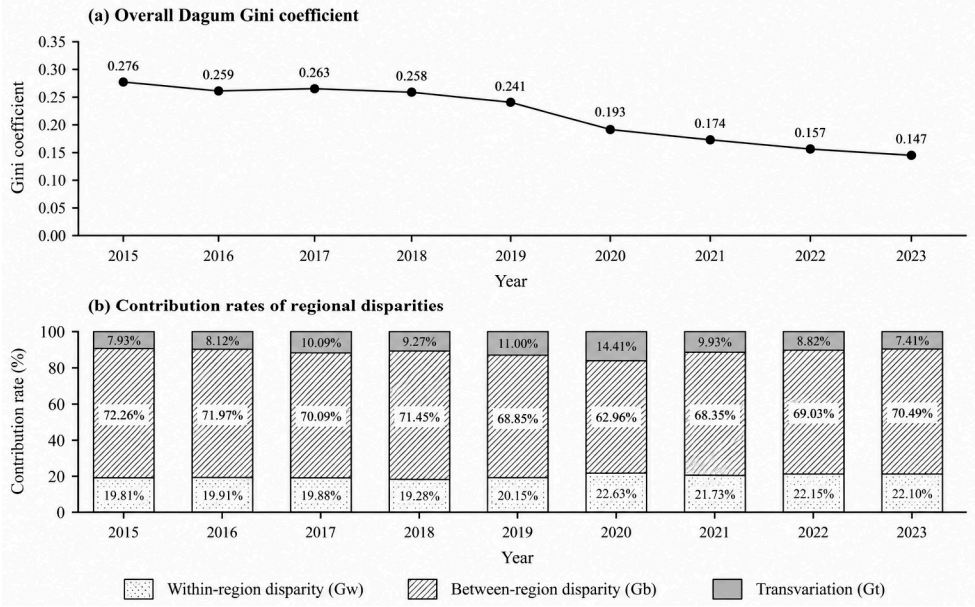


Figure 4. Evolution of the overall Dagum Gini coefficient and the contributions of its decomposition components, 2015–2023.

The decomposition results reveal that net between-region disparities remained the dominant source of overall inequality, accounting for 62.96–72.26% of the total Gini coefficient throughout the study period. Their absolute contribution decreased from 0.200 in 2015 to 0.104 in 2023, while their contribution rate declined slightly from 72.26% to

70.49%. The absolute contribution of within-region disparities also decreased from 0.055 to 0.033, although their contribution rate increased from 19.81% to 22.10%. Meanwhile, the transvariation component declined from 0.022 to 0.011, with its contribution rate fluctuating between 7.41% and 14.41%. These findings indicate that all three components contributed to the reduction in overall disparities, while net between-region disparities remained the principal source of inequality. Taken together with the results in Sections 5.2.1 and 5.2.2, the decomposition suggests that the narrowing of regional disparities was accompanied by persistent differences both within and between geographical regions.

5.3. Coupling Coordination Among Talent Service Subsystems

Using the entropy weight–TOPSIS method, this study calculated the development scores of the talent service supply, demand, and environment subsystems and subsequently applied the coupling coordination model to evaluate their coordinated development. To distinguish changes in overall development from changes in relative subsystem balance, the analysis considers the three subsystem scores, the coupling degree (C), the comprehensive development index (T), and the coupling coordination degree (D). The provincial coupling coordination degrees for 2015–2023 are presented in Table 3.

The three subsystems exhibited different development trajectories over the study period. At the national level, the average supply subsystem score increased from 0.096 in 2015 to 0.479 in 2023, representing the largest absolute increase among the three dimensions. The environment subsystem score rose from 0.276 to 0.387, whereas the demand subsystem score increased more modestly from 0.157 to 0.192. Consequently, the relative configuration of the three subsystems changed substantially. Supply recorded the lowest average score in 2015 but the highest in 2023, while demand became the lowest-scoring subsystem. These results indicate that improvements in the three dimensions were uneven, with supply-related conditions advancing more rapidly than demand-related conditions.

Regional comparisons reveal further differences in subsystem development. In 2023, the eastern region recorded relatively high scores for environment (0.512) and supply (0.483), compared with demand (0.288). The northeastern region exhibited a supply score of 0.536, exceeding its environment (0.294) and demand (0.192) scores. A similar pattern was observed in the central region, where supply reached 0.564, compared with 0.372 for environment and 0.153 for demand. The western region recorded relatively low scores across all three subsystems, particularly demand (0.125), followed by environment (0.305) and supply (0.414). These findings highlight differences in the relative development of the three subsystems across regions. In particular, environmental conditions were relatively less developed than supply-related conditions in the Northeast, while substantial differences between supply and demand scores were observed in the central and western regions. These differences should be interpreted as relative scores within the evaluation framework rather than direct evidence of actual market supply–demand imbalances.

The coupling coordination results indicate an overall increase in the coordination index of regional talent service systems. As shown in Table 3, the national average coupling coordination degree increased from 0.373 in 2015 to 0.553 in 2023. However, the coupling degree and comprehensive development index followed different trajectories. The national average coupling degree increased only moderately, from 0.848 to 0.884, whereas the comprehensive development index rose from 0.176 to 0.352. This contrast suggests that the improvement in the coupling coordination degree was accompanied by a substantial increase in overall subsystem development, while changes in relative subsystem balance were comparatively limited. Therefore, an increase in the coupling coordination degree should not be interpreted as evidence of an equivalent improvement in subsystem balance.

Table 3. Coupling coordination degree of talent service subsystems in China, 2015–2023.

Area	Province	2015	2016	2017	2018	2019	2020	2021	2022	2023
Entire Country	Average	0.373	0.389	0.413	0.438	0.468	0.501	0.524	0.539	0.553
East Area	Beijing	0.492	0.471	0.489	0.488	0.657	0.656	0.668	0.682	0.685
	Tianjin	0.371	0.391	0.445	0.478	0.554	0.559	0.570	0.573	0.575
	Hebei	0.325	0.390	0.386	0.418	0.440	0.454	0.482	0.501	0.532
	Shanghai	0.579	0.584	0.591	0.597	0.614	0.637	0.675	0.653	0.665
	Jiangsu	0.590	0.583	0.584	0.617	0.632	0.641	0.654	0.660	0.669
	Zhejiang	0.534	0.551	0.569	0.585	0.589	0.609	0.622	0.638	0.650
	Fujian	0.329	0.339	0.365	0.479	0.480	0.517	0.547	0.578	0.596
	Shandong	0.520	0.518	0.527	0.543	0.543	0.564	0.583	0.595	0.612
	Guangdong	0.416	0.439	0.555	0.628	0.633	0.652	0.672	0.675	0.677
	Hainan	0.326	0.331	0.326	0.346	0.378	0.418	0.461	0.500	0.523
	Average	0.448	0.460	0.484	0.518	0.552	0.571	0.593	0.606	0.618
Northeast Area	Heilongjiang	0.371	0.367	0.378	0.396	0.412	0.451	0.465	0.511	0.526
	Liaoning	0.430	0.437	0.505	0.524	0.548	0.557	0.572	0.578	0.590
	Jilin	0.379	0.402	0.479	0.483	0.502	0.522	0.523	0.536	0.552
	Average	0.393	0.402	0.454	0.468	0.487	0.510	0.520	0.542	0.556
Central Area	Shanxi	0.319	0.329	0.343	0.343	0.352	0.369	0.481	0.497	0.514
	Anhui	0.359	0.448	0.432	0.442	0.494	0.504	0.538	0.566	0.582
	Jiangxi	0.343	0.360	0.446	0.503	0.544	0.538	0.557	0.562	0.565
	Henan	0.371	0.377	0.370	0.426	0.429	0.468	0.504	0.537	0.548
	Hubei	0.375	0.385	0.484	0.514	0.530	0.547	0.559	0.576	0.597
	Hunan	0.380	0.381	0.390	0.464	0.495	0.523	0.540	0.551	0.562
	Average	0.358	0.380	0.411	0.449	0.474	0.492	0.530	0.548	0.561
West Area	Inner Mongolia	0.309	0.313	0.321	0.322	0.330	0.399	0.441	0.478	0.503
	Guangxi	0.286	0.292	0.308	0.377	0.415	0.432	0.462	0.492	0.507
	Chongqing	0.370	0.381	0.383	0.402	0.421	0.480	0.492	0.496	0.504
	Sichuan	0.406	0.425	0.483	0.479	0.512	0.557	0.576	0.569	0.584
	Guizhou	0.242	0.264	0.285	0.306	0.383	0.440	0.454	0.475	0.484
	Yunnan	0.278	0.290	0.293	0.308	0.312	0.415	0.430	0.467	0.493
	Shaanxi	0.379	0.449	0.455	0.464	0.477	0.522	0.539	0.546	0.569
	Gansu	0.304	0.313	0.317	0.330	0.399	0.461	0.465	0.470	0.485
	Qinghai	0.265	0.279	0.281	0.296	0.316	0.331	0.351	0.347	0.360
	Ningxia	0.292	0.291	0.288	0.307	0.330	0.419	0.436	0.454	0.464
	Xinjiang	0.251	0.292	0.317	0.288	0.306	0.388	0.397	0.413	0.431
	Average	0.307	0.326	0.339	0.353	0.382	0.440	0.458	0.473	0.489

To further examine relative subsystem balance, the coefficient of variation (CV) was calculated across the three subsystem scores for each province-year observation, with the national and regional trends iluustrated in Figure 5. A lower CV indicates smaller relative differences among the subsystems. At the national level, the average CV decreased from 0.487 in 2015 to 0.432 in 2023, suggesting an overall reduction in relative subsystem disparities. Nevertheless, the average CV reached 0.430 in 2019, indicating that improvements in subsystem balance were not continuous throughout the study period.

At the regional level, all four regions experienced increases in their average coupling coordination degrees, but their changes in relative subsystem balance differed. The eastern region maintained the highest average coupling coordination degree, increasing from 0.448 in 2015 to 0.618 in 2023. Its average CV declined from 0.534 to 0.387, accompanied by an increase in the coupling degree from 0.787 to 0.900, indicating that higher coordination index values were accompanied by smaller relative differences among subsystems. The northeastern region exhibited a contrasting pattern: although its average coupling coor-

dination degree increased from 0.393 to 0.556, its coupling degree declined from 0.951 to 0.912, while its CV increased from 0.321 to 0.424. Meanwhile, its comprehensive development index increased from 0.163 to 0.341. Thus, the increase in the Northeast's coupling coordination degree was accompanied by higher overall subsystem development despite widening relative differences among the three subsystems. The central region recorded the largest absolute increase in the coupling coordination degree, from 0.358 to 0.561, while its CV declined from 0.507 to 0.465. In the western region, the coupling coordination degree increased from 0.307 to 0.489, whereas CV declined only slightly from 0.479 to 0.457. These findings demonstrate that increases in coupling coordination degrees can coexist with different patterns of subsystem balance.

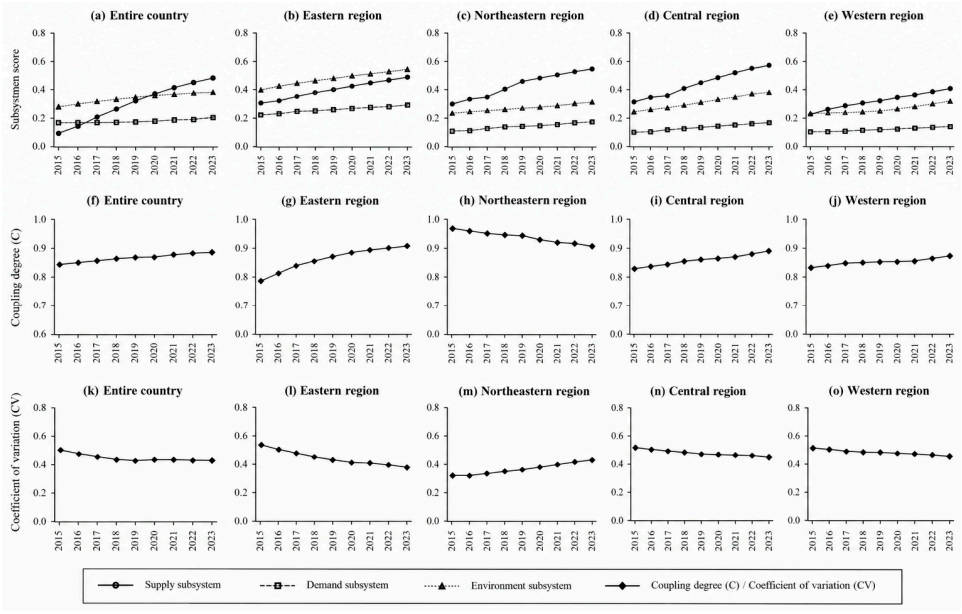


Figure 5. Evolution of subsystem development levels and relative balance across regions, 2015–2023.

Provincial differences remained evident in 2023. Beijing (0.685), Guangdong (0.677), Jiangsu (0.669), Shanghai (0.665), and Zhejiang (0.650) recorded the highest coupling coordination degrees, whereas Qinghai (0.360), Xinjiang (0.431), Ningxia (0.464), Guizhou (0.484), and Gansu (0.485) recorded the lowest values. A comparison between Beijing and Qinghai further illustrates the distinction between coupling and coordination. Qinghai's coupling degree (0.914) exceeded that of Beijing (0.878), but its comprehensive development index (0.142) was substantially lower than Beijing's (0.535), resulting in a much lower coupling coordination degree. This comparison demonstrates that a relatively high coupling degree does not necessarily imply a high coupling coordination degree when overall subsystem development remains limited.

Taken together, the results indicate that the improvement in regional talent service coordination indices during 2015–2023 was accompanied by substantial growth in overall subsystem development, while changes in relative subsystem balance varied across regions. The coupling coordination model provides a descriptive assessment of the joint development characteristics of the supply, demand, and environment subsystems; it does not establish causal interactions among them or independently validate their actual coordination performance.

5.4. Robustness Checks

5.4.1. Robustness of Talent Service Development Assessment

To assess the robustness of the talent service development assessment, the entropy-weight TOPSIS method was replaced with equal-weight TOPSIS, assigning equal weights

to all evaluation indicators. The robustness analysis was conducted for each year from 2015 to 2023. For brevity, Table 4 reports the national and regional composite scores for 2015 and 2023 only. In addition, Spearman's rank correlation coefficients were calculated annually to examine the consistency of provincial rankings under the two weighting schemes.

Table 4. Robustness of Talent Service Development Assessment under Alternative Weighting Methods.

Region/Indicator	Entropy-Weight TOPSIS (2015)	Equal-Weight TOPSIS (2015)	Entropy-Weight TOPSIS (2023)	Equal-Weight TOPSIS (2023)
National	0.179	0.269	0.325	0.419
Eastern	0.27	0.333	0.404	0.47
Northeastern	0.167	0.269	0.312	0.409
Central	0.158	0.266	0.326	0.421
Western	0.112	0.213	0.256	0.374
Spearman's ρ	—	0.953 ***	—	0.949 ***

Entropy-weight TOPSIS represents the baseline method, while equal-weight TOPSIS serves as an alternative weighting method. The analysis covers all nine years (2015–2023), although only the initial and final years are presented for brevity. Spearman's ρ measures the correlation between provincial rankings obtained using the two methods. The annual Spearman correlation coefficients ranged from 0.947 to 0.979, with an average of 0.956. *** $p < 0.001$.

As shown in Table 4, the national average composite score increased from 0.269 in 2015 to 0.419 in 2023 under equal weighting, consistent with the upward trend observed under entropy weighting (from 0.179 to 0.325). All four regions also exhibited increasing composite scores under both weighting schemes. Moreover, the eastern region consistently ranked highest and the western region lowest throughout the study period, regardless of the weighting method. Regional rankings were identical in eight of the nine years, with only a minor difference in the relative positions of the central and northeastern regions in 2021. At the provincial level, the annual Spearman rank correlation coefficients ranged from 0.947 to 0.979, with an average of 0.956 (all $p < 0.001$), indicating a high degree of ranking consistency between the two methods. Although the absolute composite scores and some individual rankings differed, the overall development trends and broad regional patterns remained stable. These findings support the robustness of the talent service development assessment to changes in indicator weighting.

5.4.2. Robustness of Regional Disparity Analysis

To examine the robustness of the regional disparity analysis, the Dagum Gini coefficient and its decomposition were recalculated using the talent service development scores obtained from equal-weight TOPSIS. The robustness analysis covered all nine years from 2015 to 2023. For brevity, Table 5 reports the results for 2015 and 2023 only.

As shown in Table 5, the overall Dagum Gini coefficient decreased from 0.145 in 2015 to 0.075 in 2023 under equal weighting, representing a reduction of 48.28%, which is consistent with the 46.74% reduction observed under entropy weighting. The decomposition results also remained stable across the two methods. Net between-region disparities consistently accounted for the largest share of overall inequality, contributing 60.99–71.69% under equal weighting and 62.96–72.26% under entropy weighting. Furthermore, both methods revealed declining within-region disparities in the eastern, central, and western regions, alongside a slight increase in the northeastern region between 2015 and 2023. All six pairwise interregional Gini coefficients declined over the study period, with the eastern–western disparity remaining the largest throughout. Although the absolute Gini coefficients differed between the two weighting methods, the main findings regarding the reduction in overall regional disparities, the dominant contribution of net between-region differences, and the

broad spatial patterns of inequality remained consistent. These results further support the robustness of the regional disparity analysis.

Table 5. Robustness of Regional Disparity Analysis under Alternative Weighting Methods.

Indicator	Entropy-Weight TOPSIS (2015)	Equal-Weight TOPSIS (2015)	Entropy-Weight TOPSIS (2023)	Equal-Weight TOPSIS (2023)
Overall Dagum Gini coefficient	0.276	0.145	0.147	0.075
Within-region contribution (%)	19.81	20.64	22.1	20.4
Net between-region contribution (%)	72.26	69.74	70.49	69.96
Transvariation contribution (%)	7.93	9.62	7.41	9.64
Eastern–Western Gini coefficient	0.429	0.228	0.23	0.117

Entropy-weight TOPSIS represents the baseline method, while equal-weight TOPSIS serves as an alternative weighting method. The analysis was conducted for all nine years (2015–2023), although only 2015 and 2023 are reported for brevity. Contribution rates are expressed as percentages. The Eastern–Western Gini coefficient measures the disparity between the eastern and western regions.

5.4.3. Robustness of Coupling Coordination Analysis

To assess the robustness of the coupling coordination analysis, a sensitivity analysis was conducted by adjusting the relative weights assigned to the talent service supply, demand, and environment subsystems. In addition to the baseline equal-weight scheme (1/3, 1/3, 1/3), three alternative schemes were considered: supply-priority (0.50, 0.25, 0.25), demand-priority (0.25, 0.50, 0.25), and environment-priority (0.25, 0.25, 0.50). The coupling degree was held constant, while the comprehensive development index and coupling coordination degree were recalculated under each scheme. The analysis covered all nine years from 2015 to 2023, with Table 6 presenting the results for 2015 and 2023 for brevity.

Table 6. Robustness of Coupling Coordination Analysis under Alternative Subsystem Weighting Schemes.

Region/Year	Baseline	Supply-Priority	Demand-Priority	Environment-Priority
		2015		
National	0.373	0.352	0.367	0.399
Eastern	0.448	0.424	0.438	0.479
Northeastern	0.393	0.378	0.393	0.408
Central	0.358	0.331	0.354	0.385
Western	0.308	0.29	0.301	0.331
		2023		
National	0.553	0.578	0.52	0.56
Eastern	0.619	0.629	0.592	0.633
Northeastern	0.556	0.594	0.525	0.547
Central	0.561	0.599	0.519	0.563
Western	0.49	0.515	0.455	0.496
Spearman's ρ (2023)	—	0.961	0.976	0.989

The baseline scheme assigns equal weights (1/3, 1/3, 1/3) to the supply, demand, and environment subsystems. The three alternative schemes assign a weight of 0.50 to the prioritized subsystem and 0.25 to each of the other two subsystems. The coupling degree is held constant across schemes. The robustness analysis covers all nine years from 2015 to 2023, although only the initial and final years are reported for brevity. Spearman's ρ measures the consistency of provincial rankings between each alternative scheme and the baseline scheme.

As shown in Table 6, the national coupling coordination degree increased under all four weighting schemes between 2015 and 2023. Under the baseline scheme, it increased from 0.373 to 0.553, while the corresponding values increased from 0.352 to 0.578 under the

supply-priority scheme, from 0.367 to 0.520 under the demand-priority scheme, and from 0.399 to 0.560 under the environment-priority scheme. The broad regional pattern remained stable, with the eastern region consistently exhibiting the highest coupling coordination degree and the western region the lowest. However, the relative positions of the central and northeastern regions varied under certain weighting schemes. At the provincial level, the annual Spearman rank correlation coefficients between the baseline and alternative schemes ranged from 0.961 to 0.993, indicating a high degree of ranking consistency throughout the study period. Overall, these results support the robustness of the main findings regarding the improvement in coupling coordination and its broad regional distribution pattern, although some regional rankings remain sensitive to changes in subsystem weights.

5.4.4. Association with Regional Economic Development

To examine the extent to which the regional talent service development index is associated with general economic development, this study conducted Spearman's rank correlation analysis between provincial GDP per capita and the overall talent service index, as well as its three constituent subsystems. As shown in Table 7, the overall index exhibits a strong positive correlation with GDP per capita ($\rho = 0.794$, 95% CI: 0.737–0.840, $p < 0.001$). However, the strength of this association varies across subsystems. Talent service environment shows the strongest correlation ($\rho = 0.795$), followed by talent service demand ($\rho = 0.687$), while talent service supply exhibits a comparatively weaker correlation ($\rho = 0.444$).

Table 7. Spearman correlations between GDP per capita and regional talent service development indices.

Index	Spearman's ρ	95% CI	*p*-Value
Overall talent service development	0.794	0.737–0.840	<0.001
Talent service supply	0.444	0.337–0.539	<0.001
Talent service demand	0.687	0.610–0.751	<0.001
Talent service environment	0.795	0.739–0.841	<0.001

The reported *p*-values and confidence intervals are based on conventional Spearman correlation analysis without adjustment for within-province dependence.

The observed differences are consistent with the functional characteristics of the three subsystems. Talent service environment encompasses economic conditions, digital infrastructure, educational resources, healthcare, transportation, and ecological conditions, several of which are closely associated with regional economic development. Talent service demand reflects potential service needs arising from employment, business activities, and innovation, which may also be greater in economically developed regions. In contrast, talent service supply focuses more directly on the organizational, platform, and public service foundations of talent service provision. Its comparatively lower correlation with GDP per capita suggests that the development of talent service supply does not necessarily correspond to regional economic development to the same extent as the other two subsystems.

Overall, these results indicate that regional talent service development is closely associated with economic development, but this association is not uniform across its constituent dimensions. The differences in correlation coefficients are consistent with the multidimensional nature of the proposed evaluation framework, in which supply, demand, and environment capture distinguishable yet interrelated aspects of regional talent service development. Nevertheless, the strong correlation between the overall index and GDP per capita indicates that broader socioeconomic development may contribute substantially to the observed regional differences. Therefore, the correlation analysis provides a supplementary

assessment of the index's relationship with general economic development, rather than conclusive evidence of its discriminant validity.

6. Discussion

The findings reveal that regional talent service development in China was characterized by overall improvement alongside persistent spatial disparities between 2015 and 2023. Although the eastern region consistently maintained its leading position, the overall Dagum Gini coefficient declined from 0.276 to 0.147, indicating a substantial reduction in regional inequality. Nevertheless, net between-region disparities remained the predominant source of overall inequality throughout the study period. Previous studies have documented spatial disparities in China's talent competitiveness at different geographical scales. Hu et al. [6] examined the spatial and temporal evolution of talent competitiveness in Western China, while Yang et al. [7] investigated regional disparities and spatial convergence in innovation talent competitiveness across China. Specifically, Yang et al. [7] reported an average overall Dagum Gini coefficient of 0.33 for regional innovation talent competitiveness during 2010–2021, with between-region differences contributing 70.685% to overall inequality. Although differences in measurement constructs and study periods limit direct comparisons of Gini magnitudes, the dominant contribution of between-region disparities is consistent with the present study (72.26% in 2015 and 70.49% in 2023). Building on these studies, the present research extends the analytical focus from talent competitiveness to regional talent service systems, examining both changes in overall development levels and the structural sources of regional inequality. The persistence of regional disparities may be associated with differences in industrial structures, innovation capacity, human capital accumulation, and institutional resources across regions. Economically developed regions may benefit from stronger talent service infrastructure and more favorable conditions for talent-related activities, whereas less-developed regions may face constraints in service provision and supporting environments. However, these factors represent plausible explanations rather than empirically established causal mechanisms. From a sustainability perspective, the coexistence of overall improvement and persistent regional disparities highlights the importance of considering not only aggregate development levels but also the geographical distribution of talent service capacity and supporting conditions. The additional correlation analysis places these spatial patterns in a broader economic context: the overall index is strongly associated with provincial GDP per capita (Spearman's $\rho = 0.794$), consistent with the role of regional economic resources in supporting talent-related activities. Yet this association should not be interpreted as independent validation, because GDP per capita is itself included in the economic environment dimension. Moreover, the pooled correlations are descriptive and do not account for within-province dependence or common time trends.

The coupling coordination analysis provides further insights into the multidimensional development of regional talent service systems. Although the coupling coordination degree increased across all four regions during the study period, improvements in this composite indicator did not necessarily correspond to greater balance among talent service supply, demand, and environment. The supplementary coefficient of variation (CV) analysis shows that the national average CV declined from 0.487 in 2015 to 0.432 in 2023, suggesting an overall reduction in relative differences among the three subsystems. However, considerable regional heterogeneity was observed. In the eastern region, the increase in the coupling coordination degree was accompanied by a decline in CV, indicating simultaneous improvements in the composite coordination index and relative subsystem balance. By contrast, the northeastern region exhibited a divergent pattern: its coupling coordination degree increased from 0.393 to 0.556, while its coupling degree declined from 0.951 to 0.912 and its CV increased from 0.321 to 0.424. This finding indicates that improvements in the coupling

coordination degree can occur alongside widening relative differences among subsystem development levels when overall subsystem development increases. The relatively limited reduction in CV observed in the western region further suggests that improvements in composite coordination indices do not necessarily imply substantial progress toward balanced subsystem development. Previous research has highlighted the role of human resource services and their relationships with talent, innovation, and industrial development [2,3]. Other studies have emphasized the relevance of regional attractiveness and urban amenities to talent mobility and location choices [4,18]. Building on these insights, the present study examines talent service supply, demand, and environment within an integrated analytical framework and further distinguishes changes in overall subsystem development from changes in their relative balance. Previous studies have also examined the relationships between human capital allocation, regional public services, and sustainable regional development [38,39]. The present findings complement this literature by highlighting the importance of considering both overall development and internal structural balance when evaluating regional talent service systems. Nevertheless, the coupling coordination model and CV analysis provide descriptive evidence of subsystem development and relative dispersion rather than direct evidence of causal interactions or actual service effectiveness. The differing correlations of GDP per capita with service supply ($\rho = 0.444$), demand ($\rho = 0.687$), and environment ($\rho = 0.795$) further underline why the three subsystems should be examined separately: their associations with general economic development are not uniform, even though they are interrelated. These differences are descriptive and do not, by themselves, establish that the subsystems are statistically distinct.

Taken together, this study contributes to the literature on regional talent development in three respects. First, it extends existing research on talent competitiveness and human resource service industry development [6,7,10] by conceptualizing regional talent service as an integrated system comprising service supply, talent demand, and environmental support. Rather than focusing exclusively on talent resources, competitiveness, or the development of the human resource service industry, this framework incorporates multiple dimensions of the regional conditions supporting talent services. Second, by combining longitudinal development assessment with the Dagum Gini decomposition, the study distinguishes improvements in overall development levels from changes in spatial disparities and identifies the structural sources of regional inequality. This approach provides a more differentiated understanding of regional talent service development by showing that reductions in overall inequality can coexist with persistent between-region disparities. Third, by complementing coupling coordination analysis with a CV-based assessment of subsystem balance, the study demonstrates that increases in coupling coordination degrees may be accompanied by either narrowing or widening relative differences among subsystem development levels. This finding refines the interpretation of coupling coordination indices by distinguishing improvements in composite coordination measures from changes in internal structural balance. This interpretation also clarifies the scope of the sustainability perspective adopted here. Environmental quality is one of several conditions supporting talent service development, but it is represented by only one indicator—days with good air quality—which receives an entropy weight of 0.020. Because entropy weights reflect variation in the pooled observations rather than intrinsic or policy importance, this relatively low weight should not be taken to imply that ecological conditions are unimportant. At the same time, the index is not intended to measure environmental sustainability comprehensively; its contribution is to assess the long-term development, geographical distribution, and structural balance of regional talent service systems. Overall, the study provides an integrated analytical perspective that considers development levels, spatial disparities, and subsystem balance

simultaneously, offering a more comprehensive basis for understanding the evolution of regional talent service systems and their implications for sustainable regional development.

7. Conclusions and Policy Implications

7.1. Conclusions

This study evaluated the development of regional talent service systems across 30 provincial-level regions in mainland China from 2015 to 2023, using an integrated framework comprising talent service supply, demand, and environment. By combining the entropy-weight TOPSIS method, Dagum Gini coefficient decomposition, and coupling coordination analysis with a supplementary assessment of subsystem balance, the study examined the temporal evolution, spatial disparities, and multidimensional development characteristics of regional talent service systems.

Three main conclusions can be drawn. First, the overall level of regional talent service development increased during the study period, although substantial geographical differences remained. The eastern region consistently exhibited the highest development level, while the western and northeastern regions generally lagged behind. Second, regional disparities declined over time, as reflected in the decrease in the overall Dagum Gini coefficient from 0.276 in 2015 to 0.147 in 2023. Nevertheless, net between-region differences remained the largest contributor to overall inequality, indicating that the reduction in regional disparities did not eliminate the underlying spatial differentiation. Third, the coupling coordination degree increased across all four regions, but improvements in this composite indicator were not uniformly accompanied by greater subsystem balance. Although the national average CV declined from 0.487 to 0.432, the northeastern region experienced an increase in CV despite an improvement in its coupling coordination degree. These findings demonstrate the importance of distinguishing overall development, spatial disparities, and relative subsystem balance when evaluating regional talent service systems.

The robustness checks further indicated that the principal findings were generally consistent under alternative indicator-weighting and subsystem-weighting schemes, although some regional comparisons remained sensitive to methodological choices. Overall, the study provides a multidimensional assessment of regional talent service development and highlights the relevance of considering both spatial inequality and internal structural balance when discussing sustainable regional development.

7.2. Policy Implications

The findings suggest that policies aimed at improving regional talent service systems should account for differences in development levels and subsystem characteristics across regions. In the eastern region, where talent service development and coupling coordination levels were relatively high, policy efforts could place greater emphasis on improving service quality, facilitating the sharing of talent service resources, and strengthening connections between service provision and evolving industrial and innovation needs. In the central region, where the coupling coordination degree increased substantially, further improvements could focus on sustaining the development of talent service capacity while addressing remaining differences among the supply, demand, and environment subsystems. For the western region, which continued to exhibit relatively low development and coupling coordination levels, strengthening basic talent service capacity and supporting conditions may be particularly relevant. In the northeastern region, where the coupling coordination degree increased despite widening relative differences among subsystems, policy attention should extend beyond improvements in aggregate development levels to the identification and management of subsystem imbalances. These recommendations should be adapted to provincial conditions rather than applied uniformly across each broad geographical region.

At the system level, policy evaluation should distinguish improvements in overall talent service development from changes in the relative balance among supply, demand, and environment. The findings indicate that increases in coupling coordination degrees do not necessarily imply a more balanced subsystem structure. Therefore, policymakers could consider monitoring subsystem development scores and relative dispersion alongside composite development and coordination indices to identify dimensions requiring further attention. Moreover, given that net between-region differences remained the dominant source of overall inequality, cross-regional cooperation and the sharing of talent service resources, information, and institutional experience may be useful policy directions for addressing persistent geographical disparities. However, as the present analysis is descriptive rather than causal, these policy implications should be interpreted as evidence-informed priorities rather than demonstrated effects of specific interventions.

7.3. Limitations and Future Research

This study has several limitations. First, the analysis is based on provincial-level data, which may conceal substantial differences among cities and metropolitan areas within the same province. The classification of provinces into four geographical regions may also obscure heterogeneity within these broad regional groups. Future research could employ city-level or other finer-scale data to examine the spatial distribution of talent service development in greater detail.

Second, the evaluation framework is constrained by the availability and comparability of longitudinal statistical data. Although the selected indicators capture multiple aspects of talent service supply, demand, and environment, they are primarily observable proxies and may not fully reflect actual service quality, accessibility, user satisfaction, or the effectiveness of talent service provision. The ecological environment is represented by days with good air quality alone, which limits the coverage of environmental sustainability. In addition, GDP per capita forms part of the index itself, so its correlation with the overall index involves measurement overlap and cannot serve as an independent validity test. Future studies could incorporate additional ecological and service-outcome indicators, clarify the boundaries among the three subsystems, and assess the index against external benchmarks not included in its construction.

Third, the entropy-weight TOPSIS and coupling coordination approaches involve methodological assumptions that may influence the resulting composite scores and regional comparisons. Although robustness checks using alternative weighting schemes generally supported the main findings, they do not eliminate uncertainty associated with indicator selection, normalization, weighting, or model specification. Entropy-derived weights reflect statistical variation rather than intrinsic importance, while coupling coordination degrees are descriptive composite measures rather than evidence of causal interactions or actual coordination effectiveness. Further work could compare alternative aggregation methods, examine the sensitivity of results to indicator composition, and use panel-data approaches that account for within-province dependence and shared time trends when evaluating relationships with external socioeconomic measures.

Finally, the present study identifies temporal and spatial patterns but does not establish the causal mechanisms underlying regional disparities or changes in subsystem development. Future studies could employ spatial econometric models, longitudinal causal designs, or quasi-experimental approaches, where suitable data and identification conditions are available, to investigate the roles of industrial structure, innovation capacity, institutional support, and talent mobility. Comparative studies across countries or regions could also assess the applicability of the supply–demand–environment framework in different institutional and developmental contexts.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su182111195/s1, Supplementary Dataset S1: Regional talent service system dataset for 30 provincial-level regions in China, 2015–2023.

Author Contributions: Conceptualization, Y.A. and Y.L.; methodology, Y.A.; validation, Y.A., M.J. and Y.L.; formal analysis, Y.A.; investigation, Y.A. and M.J.; data curation, Y.A. and M.J.; writing—original draft preparation, Y.A.; writing—review and editing, Y.A., M.J. and Y.L.; visualization, Y.A.; supervision, Y.L.; project administration, Y.L.; Funding acquisition: Y.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Social Science Fund of China, grant number 21AGL018.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting the findings of this study are provided in the Supplementary Materials (Supplementary Dataset S1). The dataset includes the underlying indicator data, processed provincial panel data, indicator weights, and the main analytical results for 30 provincial-level regions in China from 2015 to 2023. The original data were compiled from publicly available statistical sources and the Qichacha database, as described in Section 4.2 and Appendix A.

Acknowledgments: During the preparation of this manuscript, the authors used ChatGPT (Gpt-6, OpenAI) for English language editing and improving the clarity of expression. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Table A1. Measurement indicators of the talent service evaluation index system.

Dimension	Indicator	Measurement	Data Source
Talent service supply	Relative scale of newly registered human resource service enterprises	Number of newly registered human resource service enterprises/Number of corporate legal entities	Qichacha
	Scale of human resource service industrial parks	ln(1 + Number of human resource service industrial parks)	Publicly available information on provincial and municipal human resource service industrial parks
	Share of social security and employment expenditure	Local government expenditure on social security and employment/Local general public budget expenditure	National Bureau of Statistics of China
Talent service demand	Relative scale of undergraduate graduates	Number of undergraduate graduates/Total population	Provincial education statistics published by the Ministry of Education of China; National Bureau of Statistics of China
	Relative scale of postgraduate graduates	Number of postgraduate graduates/Total population	Provincial education statistics published by the Ministry of Education of China; National Bureau of Statistics of China
	Relative scale of urban unit employees	Number of employees in urban units/Total population	National Bureau of Statistics of China
	Relative scale of corporate legal entities	Number of corporate legal entities/Total population	National Bureau of Statistics of China

Table A1. *Cont.*

Dimension	Indicator	Measurement	Data Source
	Share of high-tech enterprises	Number of high-tech enterprises/Number of corporate legal entities	EPS Data Platform (China High-tech Industry Database); National Bureau of Statistics of China
	Relative scale of university R&D projects	Number of university R&D projects/Total population	EPS Data Platform (China Science and Technology Industry Database); National Bureau of Statistics of China
Talent service environment	Economic development level	GDP per capita	National Bureau of Statistics of China
	Openness level	Total imports and exports/Regional GDP	National Bureau of Statistics of China
	Relative scale of broadband access subscribers	Number of broadband internet subscribers/Total population	National Bureau of Statistics of China
	Scale of higher education resources	Number of regular higher education institutions	Provincial education statistics published by the Ministry of Education of China
	Number of beds in healthcare institutions	Number of beds in healthcare institutions	National Bureau of Statistics of China
	Per capita urban road area	Per capita urban road area	National Bureau of Statistics of China
	Days with good air quality	Number of days with air quality meeting Grade II or above	EPS Data Platform (China Macroeconomic Database)

Table A2. Information entropy, information utility, and entropy weights of the evaluation indicators.

First-Level Dimension	Weight	Second-Level Dimension	Weight	Third-Level Indicator	Weight
Talent service supply	0.215	Professional service supply	0.181	Relative scale of newly registered human resource service enterprises	0.068
				Scale of human resource service industrial parks	0.113
		Public service supply	0.034	Share of social security and employment expenditure	0.034
Talent service demand	0.489	Individual-level potential service demand	0.266	Relative scale of undergraduate graduates	0.037
				Relative scale of postgraduate graduates	0.149
				Relative scale of urban unit employees	0.081
		Organizational-level potential service demand	0.222	Relative scale of corporate legal entities	0.058
				Share of high-tech enterprises	0.066
				Relative scale of university R&D projects	0.099
Talent service environment	0.297	Economic environment	0.141	Economic development level	0.058
				Openness level	0.084
		Digital infrastructure	0.028	Relative scale of broadband access subscribers	0.028
		Educational resources	0.034	Scale of higher education resources	0.034
		Healthcare conditions	0.055	Number of beds in healthcare institutions	0.055
		Transportation conditions	0.018	Per capita urban road area	0.018
		Ecological environment	0.020	Days with good air quality	0.020

References

1. Diebolt, C.; Hippe, R. The long-run impact of human capital on innovation and economic development in the regions of Europe. *Appl. Econ.* **2019**, *51*, 542–563. [CrossRef]
2. Li, Y.; Chen, W. The Development and Transformation of China's Human Resource Service Industry in the Post-Epidemic Era: Based on the Context Analysis of Policies about Human Resources Service under the Normalization of Epidemic Prevention and Control. *Hum. Resour. Dev. China* **2020**, *37*, 18–32. [CrossRef]
3. Wang, Y.; Shi, M. Spatial Pattern and Driving Factors of Coupling and Coordination between Human Resource Service Industry and 'Talent Chain, Innovation Chain, and Industry Chain'. *Chin. Pers. Sci.* **2024**, *6*, 68–83. [CrossRef]
4. OECD. *Rethinking Regional Attractiveness in the New Global Environment*; OECD Publishing: Paris, France, 2023. [CrossRef]
5. Fu, Y.; Gabriel, S.A. Labor migration, human capital agglomeration and regional development in China. *Reg. Sci. Urban Econ.* **2012**, *42*, 473–484. [CrossRef]
6. Hu, W.; Ren, H.; Wang, K. Analysis of Spatial and Temporal Evolution of Talent Competitiveness in Western China. *Areal Res. Dev.* **2023**, *42*, 22–27, 41.
7. Yang, S.; Xiao, B.; Chen, J. The Spatial-Temporal Evolution and Spatial Convergence of China's Regional Innovation Talent Competitiveness. *Sci. Technol. Prog. Policy* **2025**, *42*, 126–138.
8. He, Q.; Dun, S. How do Talent Environment Factors Drive the Agglomeration of Urban Innovative Talents?—Qualitative Comparative Analysis Based on Configuration Perspective. *Sci. Manag. Res.* **2024**, *42*, 155–163.
9. Li, P.; Tang, J. Research on the Evaluation of Talent Environment in 'New First-line' Cities on the Basis of the Projection Pursuit. *Sci. Technol. Manag. Res.* **2019**, *39*, 69–75.
10. Li, Y.; Li, L. A Study on the Evaluation of the High Quality Human Resource Service Industry Development—An Empirical Study Based on Data from 2012–2020 in China. *J. Macro-Qual. Res.* **2022**, *10*, 1–14. [CrossRef]
11. Bao, Y.; Qiu, H. Research on Regional Scientific and Technological Talent Service Systems. *Sci. Technol. Manag. Res.* **2007**, *7*, 114–116.
12. Sun, H. Discussion on the Evaluation Index System of Regional Talent Services. *Hum. Resour. Dev. China* **2011**, *5*, 91–94. [CrossRef]
13. Dong, C.; Li, Y.; Zhang, T.; Wang, S. Research on Paths to Building a High-Quality Talent Service System in Hubei. *Talent. Resour. Dev.* **2022**, *4*, 21–32.
14. Benner, C. Labour flexibility and regional development: The role of labour market intermediaries. *Reg. Stud.* **2003**, *37*, 621–633. [CrossRef]
15. Giloth, R.P. The role of intermediaries in US workforce and education innovation. *Econ. Political Stud.* **2023**, *11*, 252–273. [CrossRef]
16. Chen, X. The Research about Talent Service Need Indicator System and Supply Strategy. *J. Beijing Univ. Aeronaut. Astronaut. (Soc. Sci. Ed.)* **2019**, *32*, 42–49. [CrossRef]
17. Cui, C.; Wang, Y.; Wang, Q. The Interregional Migration of Human Capital: The Case of 'First-Class' University Graduates in China. *Appl. Spat. Anal. Policy* **2022**, *15*, 397–419. [CrossRef]
18. He, J.; Song, Y.; Huang, X.; Lin, J. An amenity-based approach to excellent returning scientists' location choice in China. *Pap. Reg. Sci.* **2022**, *101*, 1181–1197. [CrossRef]
19. Hao, F.; Shao, Y.; Guan, H.; Wang, S. How urban amenities foster innovation: The mediating mechanisms of talent and high-tech enterprises in Chinese cities. *Cities* **2026**, *168*, 106463. [CrossRef]
20. Zhao, Y. Evaluation of Regional Scientific and Technological Talent Competitiveness in China During 2016–2018. *Sci. Technol. Manag. Res.* **2021**, *41*, 52–59.
21. INSEAD; Portulans Institute. *The Global Talent Competitiveness Index 2025: Talent and Resilience: Navigating in an Era of Disruption*; INSEAD: Fontainebleau, France; Portulans Institute: Washington, DC, USA, 2025.
22. Zhang, Y.; Kumar, S.; Huang, X.; Yuan, Y. Human capital quality and the regional economic growth: Evidence from China. *J. Asian Econ.* **2023**, *86*, 101593. [CrossRef]
23. Bronfenbrenner, U. *The Ecology of Human Development: Experiments by Nature and Design*; Harvard University Press: Cambridge, MA, USA, 1979.
24. Klimecki, R.G.; Litz, S.A. *Human Resource Management as Intervention in the Evolution of Human Resources*; University of Konstanz: Konstanz, Germany, 2004.
25. Shen, B. *Talent Ecology*; Blue Sky Press: Beijing, China, 2005.
26. Zhou, W. Research on Ecological Safeguarding Strategy of China's Construction of a Major World Center of Talent and Innovation. *Bus. Manag. J.* **2024**, *46*, 29–48. [CrossRef]
27. Li, Y.; Jiang, M.; An, Y. Regional Agglomeration of Human Resources Enterprises and Its Influencing Factors in China. *Hum. Resour. Dev. China* **2024**, *41*, 22–38.
28. Mao, Q.; Pang, K. The Inherent Compatibility and Interactive Paths between New Quality Productive Forces and the Modern Industrial System. *Reform* **2025**, *2*, 62–76.

29. Li, J.; Wang, H. Research on the Training Mechanism of Innovative Talents of National Strategic Scientific and Technological Strength from the Perspective of Ecological Niche. *J. Hebei Univ. (Philos. Soc. Sci.)* **2024**, *49*, 138–151.
30. Sun, R.; Sun, Y.; Sun, Y. Research on the Structure and Operation Mechanism of Talent Innovation and Entrepreneurship Ecosystem—Case Analysis Based on Suzhou Industrial Park. *Forum Sci. Technol. China* **2021**, *11*, 113–122. [CrossRef]
31. Gu, H.; Shen, T. Spatial Evolution Characteristics and Driving Forces of Chinese Highly Educated Talents. *Acta Geogr. Sin.* **2021**, *76*, 326–340. [CrossRef]
32. Ye, X.; Chen, W. Research on the City Attraction for Science and Technology Innovation Talents—Construction of Evaluation Indicator System and Empirical Analysis Based on Amenities Theory. *Stud. Sci. Sci.* **2019**, *37*, 1375–1384. [CrossRef]
33. Liu, Y.; Shen, J.; Xu, W.; Wang, G. From School to University to Work: Migration of Highly Educated Youths in China. *Ann. Reg. Sci.* **2017**, *59*, 651–676. [CrossRef]
34. Glaeser, E. Cities, Productivity, and Quality of Life. *Science* **2011**, *333*, 592–594. [CrossRef] [PubMed]
35. Zheng, S.; Zhang, X.; Sun, W.; Lin, C. Air Pollution and Elite College Graduates' Job Location Choice: Evidence from China. *Ann. Reg. Sci.* **2019**, *63*, 295–316. [CrossRef]
36. Dagum, C. A New Approach to the Decomposition of the Gini Income Inequality Ratio. *Empir. Econ.* **1997**, *22*, 515–531. [CrossRef]
37. Cai, W.; Gong, X. A Study on the Coupling and Coordination among Higher Education, Human Capital and Scientific and Technological Innovation in China. *J. High. Educ. Manag.* **2024**, *18*, 13–29, 59.
38. Li, P.; Li, X.; Yuan, G. Cross-Regional Allocation of Human Capital and Sustainable Development of China's Regional Economy—Based on the Perspective of Population Mobility. *Sustainability* **2023**, *15*, 9807. [CrossRef]
39. Wang, X.; He, T.; Li, K. Regional Population and Public Services under the Framework of Sustainable Development: Evidence from a Typical High-Tech Zone in China. *Sustainability* **2023**, *15*, 13259. [CrossRef]

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