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The Spatio-Temporal Dynamics, Driving Mechanism, and Management Strategies for International Students in China under the Background of the Belt and Road Initiatives

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Abstract: The management of international students has become a new challenge that China and most countries in the world must face in the context of the "Belt and Road Initiative" (BRI) and the globalization of higher education. In this paper, we conducted an empirical study on international students in China (ISC) based on a combination of spatial econometric models and analytical methods such as BCG, GeoDetector, and DDCAM, trying to provide a basis for "evidence-based decision-making" by the government in the management of international students and talents. Quantitative analyses revealed significant diversity and spatial effects in the spatio-temporal dynamics of ISCs, with the emergence of star, gazelle, cow, and dog types, suggesting that the scientific management of ISCs requires both local adaptation (spatial differentiation and heterogeneity) and regional collaboration (spatial correlation and autocorrelation). There were many factors affecting the spatio-temporal dynamics of ISCs, and the force of different factors varied considerably, with the key factor more than 0.5 but the auxiliary factor being less than 0.2. Moreover, the factors had significant interaction effects, and a large number of super-interacting factor pairs emerged, with a joint force of more than 0.9, twice the force of a single factor. Generally, the factors had a complex driving mechanism, suggesting that ISC management requires identifying the key and important factors, while attaching emphasis to the synergistic effects among different factors. The recommendation is that China should manage ISCs in spatial zones and introduce differentiated development strategies and policies in different zones. In conclusion, this paper proposes a technical route integrating "dynamic analysis-driving mechanism-policy design" for international students, which is applicable to China, while providing a reference for the management and spatial planning design of international students in other countries in the world.

Keywords: overseas students; spatial analysis; influence factor; policy design; China

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1. Introduction

1.1. Background

The internationalization of education in the era of knowledge economy has become a key strategy and a general consensus for the open development of education, the mobility and cultivation of talents in all countries of the world [1]. As the internationalization of higher education has become increasingly prominent in recent years, more and more students are seeking international education to lay an extensive international cultural and social foundation for upward social mobility [2,3]. International students are an important group in the study of internationalization of higher education and international mobility of talents. Their transnational mobility and geographic distribution directly affect the world's economic, political, and innovation patterns, so they have attracted extensive attention from scholars around the world [4,5].

With the "Belt and Road" Initiative and the "Study in China" Program put into effect, China's international student education has ushered in a new opportunity to significantly boost its development. China, the largest study destination country in Asia, is transforming itself from an insignificant player in the global study destinations to a dominant player in the top three (with the United States and the United Kingdom in first and second place, respectively). It has grown into a significant representative in the international student education and international mobility of talents across the world [6,7].

Therefore, it is of great theoretical and practical value to conduct an empirical study of ISCs to analyze its evolutionary dynamics, driving mechanisms, and management strategies. This empirical study provides a basis for the design of a new round of programs, plans, and policies for studying in China, and provides a reference for international student management decisions as well as for the governance of international talent mobility in similar countries around the world.

1.2. Literature Review

International student mobility has a direct impact on everyone concerned and indirectly on the policy, economic and academic global cycles of all parties involved. And it also has an impact on the internationalization of education in all countries and regions around the world [8]. Scholars have conducted extensive and wide-ranging research on international student mobility and management, and international students have long been an important object of study in the geography of talents [9,10]. To date, the study has yielded fruitful results in geographic distribution, spatial patterns, international mobility networks, and structural characteristics of international students.

1.2.1. Pattern and Characteristics of International Student Mobility

"From where?" (source) and "Where to go" (sink) are priority questions in the geography study of international students [11]. Based on the source and sink theory, scholars have discussed the geographical distribution pattern and characteristics of the sources and sinks of international students.

Motivation and Adaptation of International Students from Different Sources

From the perspective of source, the scholars analyzed the countries and regions where the majority of international students are from and their characteristics. On the international regional (supranational) scale, Hsiao [12] based on the structural analysis of the sources, studied the number and characteristics of students from Asia, America, Europe, Oceania, and other regions and countries studying in Taiwan using the gray prediction model. Jon [13] discussed the possibility of developing Korea as an international study education center in East Asia and proposed enrollment strategies for different countries. On the national scale, Hifumi [14] discussed the symbiotic learning, adaptation, and influence factors of international students on communication rules based on a questionnaire survey of 372 international students studying in Japanese universities coming from countries and regions in Asia. Yue [15] pointed out the differences in motivation for studying in China between the two groups of students through a comparative analysis of international students BRI and Non-BRI Countries.

Distribution and Structure of International Student Destinations

From the perspective of sink, the scholars analyzed the approaches of international students to the choice of study destination and to discuss the structure and characteristics of the sinks. On the global and national scale, Glass [16] and Barnett [17] studied the changes in the parameters such as relational closeness of international mobility, network centrality, and structural degree of international students, and concluded that the core-periphery structure of international students has been stable for a long period of time, and that the structure of the study abroad network has shown a trend of multipolarity. It is a remarkable fact that with the rapid growth in the number of international students

hosted by countries such as China, South Korea, and Japan, Asia has been an emerging center for international study following North America and Europe. As a result, more and more scholars have begun to look at Asia, especially China, as a sample for international student mobility studies [18]. On the international schools and urban communities scale, Castano [19] analyzed the processes and reasons why international students congregate in different schools, and to some extent discussed the spatial inequalities and characteristics of congregation of international students. Montgomery [20] found that international students tended to choose international communities in the UK for a supportive living environment to support their studies.

In addition, some scholars have analyzed the characteristics and influence factors of geographic mobility of international students by integrating the perspectives of sources and sinks [21,22], and further explored the costs and benefits of geographic mobility of international students [23]. For example, Brooks [24] analyzed the impact of the concept of "internationality" and its understanding on international student mobility, including the country and location of study, and the hierarchy and positioning of sinks. Abbas [25] revealed the key factors influencing the choice of study destination through a comparative analysis of international students admitted to the UK and Germany.

1.2.2. Structure and Relationships of International Student Network

Scholars have studied the structure and characteristics of international students' geographic, social, and virtual networks (WeChat [26] and Twitter [27]) by network analysis and further analyzed their influence factors [28].

Geographical Network and Spatial Structure of International Student Mobility

As for the geographic network, scholars have analyzed the complexity and evolution of patterns in the geographic networks of international students. For example, Choudaha [29] found that the world has experienced three waves of international student development since the turn of the new century, with the most significant feature being the increasing competition for centers in both emerging and traditional study destination countries, and that center-based countries are developing and implementing a large number of incentives to increase their attractiveness to international students. Kondakci [30] found that international students are not balanced in terms of mobility and network centrality, but rather that the network aggregation coefficient continues to decline, leading to a more fragmented community, and found that a number of regional centers are rapidly emerging in the face of declining dominance of traditional centers, and that they do not share the same internationalization processes and mobility patterns. According to them, Europe and the United States have long been firmly at the center for international students, but with the rise of emerging centers in Asia, South America, and the Middle East, they are becoming less central to the network. Notably, African countries have become increasingly marginalized, while the Middle East, Eastern Europe, and Asia have moved from marginalization to new centers [31,32]. It is important that geographic network analysis is an expansion of source and sink theory that transforms the geographic distribution of international students into a geographic relationship, making the study move from traditional geography to complex geography.

Social Relations and Capital Networks of International Student Mobility

Scholars have analyzed from the perspective of social network the ways and approaches of embedding social relations and social capital into the geographic networks of international students. For example, Collins [33] emphasized the importance of embedding the formation and change of international student mobility networks in diverse geographic and social transnational processes, where educational institutions and interpersonal relationships play an influential role. Further analysis of social networks using econometric methods revealed a high degree of spatial match between international student mobility networks and scientific cooperation networks, suggesting that international student net-

works have become an important component of social capital that influences a country's knowledge production capacity [34]. According to Beech [35], social networks of friendship and kinship are key determinants of international students' decision to pursue higher education abroad. Motos [36] further quantitatively analyzed the friendship networks of international students in Barcelona universities based on UCINET and Netdraw. Shields [37] found that the geographical concentration and spatial inequality of international students are increasing, and the international mobility of students is closely related to the changes in world trade transactions and international government organizations. Moon [38] argued that international student mobility relationships are part of transnational social capital networks, and that institutional and language barriers are major factors influencing the formation of international study-abroad networks. Overall, the research in this field introduces a new perspective of network analysis of social relations and social capital, while embedding the geographic network of international student mobility into the network of international trade, investment, and cultural exchanges to reveal the status and role of international education networks in globalization in the new era.

1.2.3. Selection and Adaptation of International Student Destination

Scholars have explored the factors influencing international students' destination choice, motivation to study abroad, and management mode through questionnaires and structural equations [39]. Nissen [40], Hechanova-Alampay [41], and Dutke [42] explained the socialization effect on motivation and outcomes of studying abroad based on a comparative analysis of international and non-international students using a questionnaire and propensity score matching methodology. It suggests that the first trimester is a difficult period of adaptation to the destination for international students, and that international students are more attracted to problem (as opposed to emotionally)-oriented social support than non-international students. Bonal [43] investigated the isolation and dynamic characteristics between international students' residential areas and schools in Barcelona, and identified private schools providing subsidies as a principal factor in the tendency of international students to concentrate and cluster in particular neighborhoods. Gargano [44] and Raja [45] analyzed the processes and strategies of international students' integration in destinations using the concept of Transnational Social Fields and semi-structured interviews, including the construction and negotiation of identities and social spaces, physical places, and imagined geographies.

1.3. Research Gap

In conclusion, current international student research reflects three deficiencies from a geographic and managerial perspective.

First, scholars have not paid enough attention to developing countries, neglecting to analyze the geographical distribution of international students in destination countries and its changes. Developing countries lag far behind developed countries in terms of the depth and details of research. The former, represented by the United States, the United Kingdom, Australia, Canada, Germany, and France [46], have gone beyond the internationalization of education and begun to expand into specialized areas such as employment and immigration of international students [47], while the latter, represented by China [48], India [49], Georgia [50], Malaysia [51], have only seen a few scholars conducting case studies [52]. Notably, the characteristics of the regional distribution of international students in the country are as important to policymakers in destination countries as their origin characteristics. As O'Connor stated, encounter sites and spaces cannot be viewed in isolation, and the study on them allows for a better analysis of the impact of different factors on the development, consolidation, deployment, and association of spatial distribution patterns of international students [53]. Therefore, it is of great value for policymakers to quantitatively analyze the distribution pattern and change characteristics of international students in the destination countries and reveal the dynamic driving mechanism of spatio-temporal evolution.

Second, existing studies fail to provide an adequate analysis of different levels of international students, especially the higher levels represented by master's and doctoral students, resulting in a disconnect between the availability of research results and actual management needs. In developing countries such as China, India, and Russia, the internationalization of education is transitioning from extensive development (increasing international students) to high-quality development (optimizing the structure of international students and improving the quality of education), and for them the management of highly educated international students, represented by master's degree and doctoral degree holders, has been a key focus of the policy design in the new period [54]. Accordingly, policymakers are eager to figure out the evolving dynamics of high-level international students at the master's and doctoral levels and their driving mechanisms to provide a basis for policy design and implementation. Only Arevalo discussed the motivation of international students from 14 countries to study for a master's degree in Europe [55]. However, most scholars focus on international students as a whole rather than categorizing them by undergraduate, master's, doctoral, and non-degree international students, and the existing research fails to meet the theoretical needs of high-level international student management practices.

Third, the policy design tools and methodologies of existing studies in international student management are underdeveloped. The experience of internationalization and development of higher education in traditional and emerging centers invariably shows that international student management policies have played a key role in their rise and transformation [56,57]. However, the existing studies are more devoted to analyzing the characteristics of its development and the process of change, without paying enough attention to international student management policies and involving the development of management tools and policy design methods. By combining the results of the analysis of international students with management practices, a technical approach that integrates "spatio-temporal dynamics, driving mechanisms, and policy design" provides guidance for the internationalization and globalization of education in countries around the world.

1.4. Objectives and Questions

ISC development is the frontier of international cooperation and opening up of education in the "Belt and Road Initiative", and plays a strategic, leading, and driving role. The different starting time, resource endowment, development stage, and target need of ISC education across provincial administrations have led to the need for different governments to formulate differentiated policies and strategic plans [58]. Based on spatial measurement models such as BCG and GeoDetector, and by quantitatively analyzing the dynamics of spatial and temporal evolution and driving mechanisms of ISC, this paper proposes a spatial zoning plan and differentiated policy design suggestions for international student management, providing a basis for local governments to formulate strategic plans for the development of a new round of higher education internationalization and globalization.

This paper focuses on the following questions:

First, what are the characteristics of ISC's geographic distribution and changes in China's provincial administrations? That is, how to quantitatively measure the spatio-temporal dynamics of ISCs in the provincial administrations?

Second, what factors affect the spatio-temporal variation in ISC? What is the relationship between different factors?

Third, how to seamlessly apply the analysis results of the above issues to strategic planning and policy design for the development of internationalization and globalization of higher education?

2. Research Design

2.1. Study Area

The study area covered 31 provincial-level administrative regions of China, including 23 provinces, 5 autonomous regions, and 4 municipalities directly under the central govern-

ment (Figure 1). Hong Kong, Macao, and Taiwan were excluded because of the absence of data and the fact that their statistical caliber was not exactly the same as that of the inland regions. The study included all ISCs and high-level international students (master's and doctoral), but the analysis of the latter excluded Tibet because as of the date of the study it received no high-level ISC.



Figure 1. Study Area.

2.2. Research Route and Steps

This paper attempted to construct a technical route integrating "dynamic analysis—driving mechanism—policy design" to provide a basis for decision-making on the management of international students and the internationalization of education. First, we collected and preprocessed ISC data and its influencing factors (independent variables) by analyzing the research on Chinese provincial administrations. Second, we analyzed the spatio-temporal dynamics of ISCs based on the BCG matrix. Third, we introduced GeoDetector to analyze the influence of the factors on the spatio-temporal dynamics of ISCs and reveal the interaction mechanism between different factors. Finally, we proposed a spatial zoning scheme for ISC management using DDCAM, laying the foundation for government decision-making and development strategic planning/policy design (Figure 2).

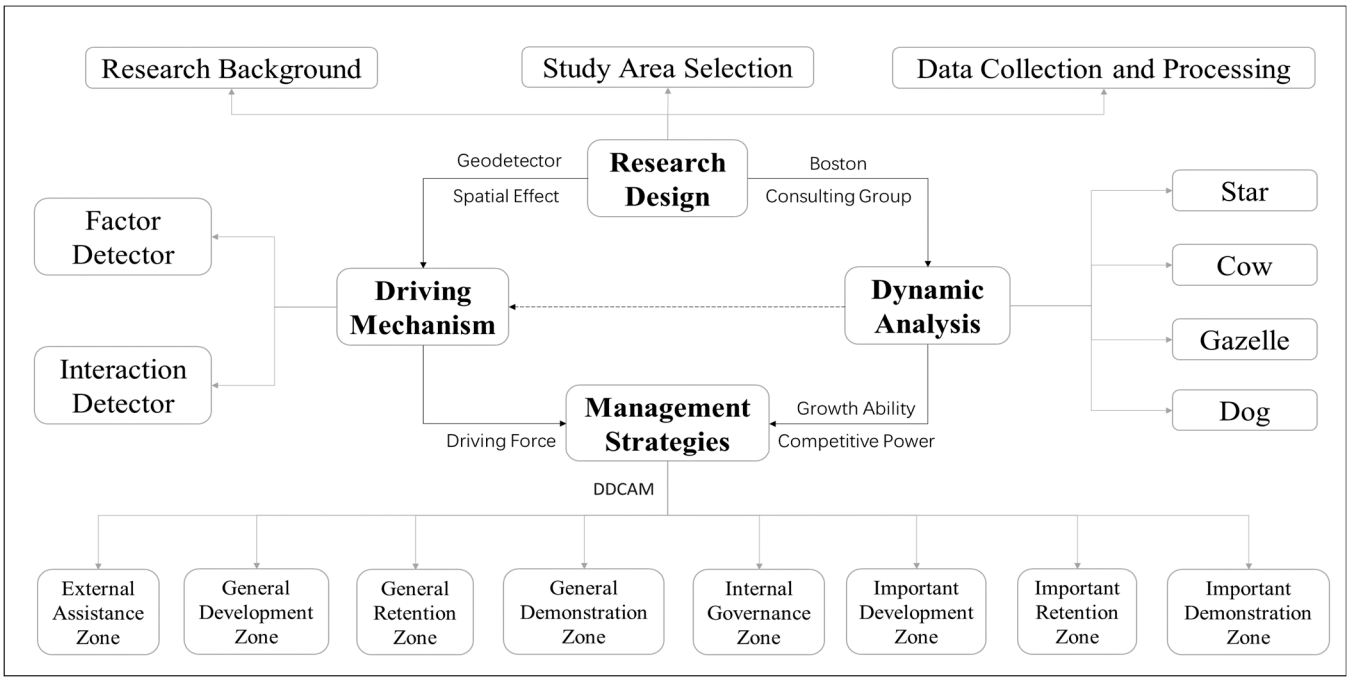


Figure 2. Research route and steps.

2.3. Research Methods and Data Source

2.3.1. Spatio-Temporal Dynamics Analysis: Boston Consulting Group (BCG) Matrix

The BCG matrix is a common systematic method for selecting and analyzing business development strategies. Since most companies engage in many business operations at the same time, relying on limited financial, human, and material resources, in order to cope with the fierce competition in the market they are forced to shift the development resources that must be prioritized to the advantageous business areas. Based on a comparative analysis of all the businesses of the company and its competitors using the BCG matrix, we presented the competition state of each business unit depending on its market position and growth ability, providing a basis for the allocation of corporate resources.

The analysis of the spatio-temporal dynamics of ISCs requires consideration of the degree of change in the temporal dimension, as well as the geographic patterns in the spatial dimension. In this paper, we took ISC's Relative Share (RS) and Growth Rate (GR) as the core indicators, and integrated the spatio-temporal dimensions using the BCG matrix to analyze the spatio-temporal dynamics of ISCs in different provincial administrations. RS stands for a spatial analysis that characterizes the national competitiveness of each provincial administrative region by calculating the ratio of the number of ISCs in a provincial administrative region to the maximum value in the study area. In contrast, GR stands for a temporal analysis that characterizes the growth capacity in the internationalization of education by calculating the rate of change of ISCs in a provincial administrative region. The equations are as [59]:

$$\text{Relative Share} = \frac{ISC_{i-end}}{ISC_{max-end}} \times 100\% \quad (1)$$

$$\text{Growth Rate} = \left(\frac{ISC_{i-end} - ISC_{i-star}}{ISC_{i-star}} - 1 \right) \times 100\% \quad (2)$$

where: ISC_{i-end} and ISC_{i-star} are the numbers of ISCs in the terminal and base periods of the i-th provincial administrative region, respectively, and $ISC_{max-end}$ is the maximum value of ISCs in the terminal study area (31 provincial administrations). To eliminate human interference and take into account the relative balance of classification results, this

paper uses the medians of RS and GR as the thresholds, marked with M_{RS} and M_{GR}. The Boston matrix and gazelle concept are commonly used in the field of business development strategy and management [60]. This paper classified the spatio-temporal dynamics of ISCs into four types of star, gazelle, cow, and dog based on their ideas on enterprise classification and management strategy. Star represents ISC's strong competitiveness and good growth, indicating that the internationalization of education is in an ideal state, and that they are the best choice for shaping and displaying the brand and image of "Study in China" in the future. Cow represents ISC's strong competitiveness but weak growth, indicating that the internationalization of education is in a bottleneck, and requires external assistance or internal reforms to activate new development dynamics in the future. Gazelle represents ISC's weak competitiveness but good growth, indicating that the new opportunities for the internationalization of education. Future studies should start from the national strategy and local needs for education internationalization based on a small sample from the gazelle region, and both the central and local governments should jointly increase investment and policy support to promote them to grow into emerging star regions in China. Dog represents ISC's weak competitiveness and growth, suggesting that the internationalization of education is at its worst, and that the regions of such type are ones marginalized and lost. Only by taking advantage of the support of the central government and new development opportunities to accelerate the transformation of strategies and trends in the internationalization of education in the dog-type regions will it be possible to reverse the unfavorable situation in the future (Figure 3).

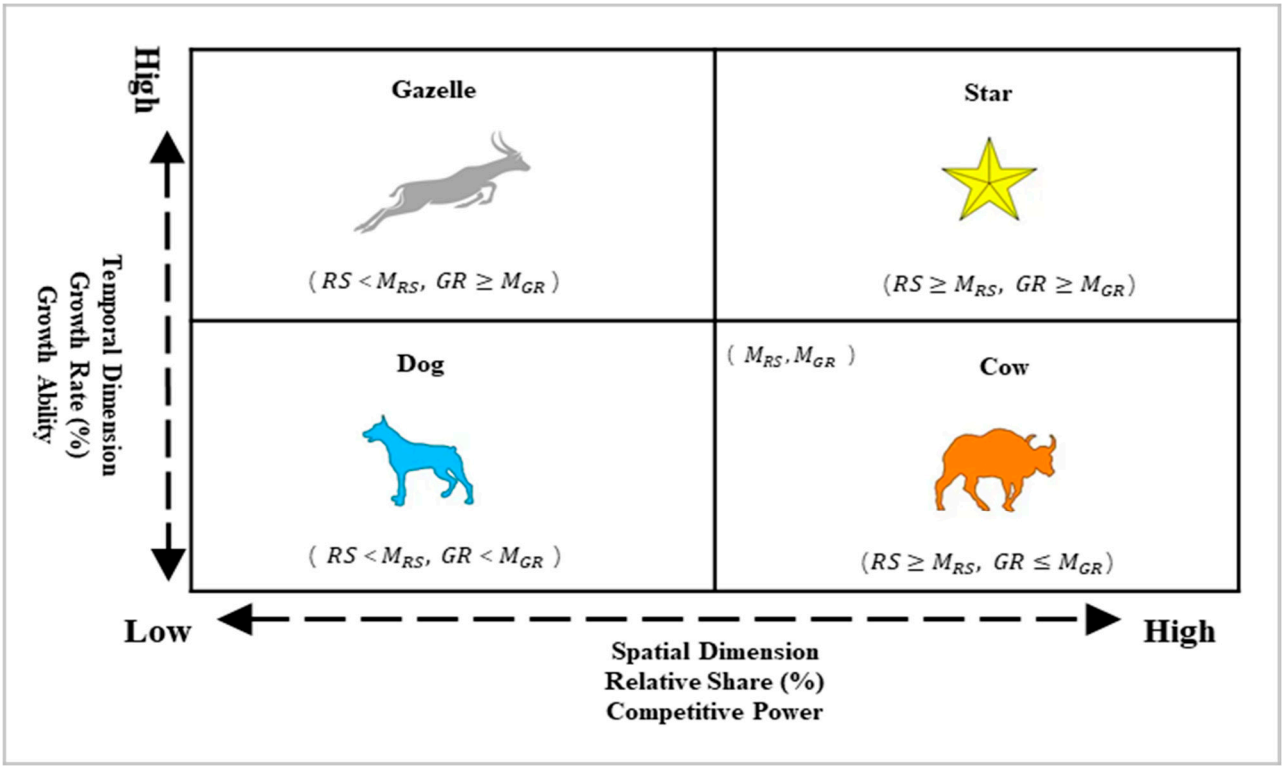


Figure 3. The spatio-temporal dynamic analysis of ISCs based on BCG.

2.3.2. Driving Mechanism: Spatial Effect Analysis and GeoDetector

Detecting the spatial effects of ISC's geographic distribution patterns before analyzing the driving mechanisms is needed to decide whether to choose a spatial measurement model (taking the effects of spatial weights into account) or a traditional regression model (taking no effects of spatial weights into account). Spatial effects include heterogeneity and correlation, and in this paper, we measured the intensity of spatial effects by the coefficient of variation in combination with Moran's I, and visualize the spatial effects with spatial

clustering map and spatial cold hotspot analysis map. The coefficient of variation (CV) was independent of the magnitude, scale, and positivity of the data, with larger values representing higher spatial heterogeneity. Guan [61] and Miyamoto [62] et al. categorized spatial heterogeneity as weak, moderate, and strong by thresholds of 0.16 and 0.36. Positive Moran's I indicates positive spatial autocorrelation in the geographic distribution of the ISC correlation metrics, and vice versa for negative spatial autocorrelation [63]. Spatial cluster analysis maps allow for dividing the study area into spatial subdivisions with similar characteristics, and visualizing patterns and features of spatial differences. Quantile-based spatial cluster analysis method is used in this paper. Spatial cold and hot spot analysis, by $Getis-Ord\ G_i^*$, divides the study area into four types of regions of hot spot, cold spot, sub-hot spot, and sub-cold spot, to visualize the spatial clustering and correlation characteristics of ISC, as follows [64,65]:

$$C_v = \frac{1}{\overline{ISC}}\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(ISC_i - \overline{ISC}\right)^2} \tag{3}$$

$$\text{Global Moran's } I = \frac{n}{W_0} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\left(ISC_i - \overline{ISC}\right)\left(ISC_j - \overline{ISC}\right)}{\sum_{i=1}^{n}\left(ISC_i - \overline{ISC}\right)^2},\ W_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} = W_{ij} \tag{4}$$

$$\text{Getis} - \text{Ord } G_i^* = \frac{\sum_{j=1}^{n} W_{ij} ISC_j - \overline{ISC}\sum_{j=1}^{n} W_{ij}}{S\sqrt{\frac{n\sum_{j=1}^{n} W_{ij}^2 - \left(\sum_{j=1}^{n} W_{ij}\right)^2}{n-1}}},\quad \overline{ISC} = \frac{\sum_{j=1}^{n} ISC_j}{n},\quad S = \sqrt{\frac{\sum_{j=1}^{n}\left(ISC_j - \overline{ISC}\right)^2}{n}} \tag{5}$$

where: C_v represents the coefficient of variation; n represents the number of provincial administrations in the study area, and ISC_i represents the number of ISCs in the i-th provincial administration; $\overline{ISC}$ is the mean value of the ISCs in the study area, W_{ij} is the spatial weight matrix (1 indicates spatial adjacency, and 0 indicates spatial non-adjacency), W_0 is the sum of the spatial weight matrices, and S is the standard deviation of the number of ISCs. The statistical significance of Getis-Ord G_i^* follows the standardized Z [66]. The values $Z > 2.58$ and $Z < -2.58$ indicate hot and cold spots, representing high-value and low-value agglomerations, i.e., the center has the same attribute values as the peripheral neighboring regions; while the values $1.96 < Z < 2.58$ and $-1.96 < Z < 1.96$ represent sub-hot and sub-cold spots, indicating isolated distribution of high and low values, i.e., the center has opposite attribute values to the periphery, with emergence of center polarization or collapse.

The geographic distribution of ISCs was influenced by multiple factors, and there were complex interactions between different factors, so this paper introduced GeoDetector to quantitatively measure the direct influence of factors and the interaction effect between different factors. The method, also called q-statistic, is an emerging spatial econometric model widely used in humanities, social and management sciences [67]. GeoDetector is an important tool for geographers to perform factor driving and interaction analysis, and this paper uses an open source version of it embedded in excel. It was created based on the statistical detection of spatial heterogeneity under the leadership of Prof. Wang Jinfeng, offering functions of factor, interaction, ecology, and risk calculation. This paper introduced factor and interaction detection functions to analyze the driving force of single factors and the interactive driving force of factor pairs. First, it discretized the independent variable (X_i) using the quantile method, i.e., dividing all provincial administrations in the study area into two to six sub-divisions. Second, it introduced the dependent (Y_i) and independent variables into the GeoDetector and introduced a factor detector and an interaction detector to compute the direct and interaction influences labeled $q(X_i)$ and $q(X_i \cap X_j)$. A larger value represents a stronger factor driving force, with a maximum value of 1. The underlying logic of GeoDetector assumes that the two spatial division schemes are more similar if the

independent variable has a stronger explanatory power for the dependent variable [68,69]. Based on the relationship between q ($X_i \cap X_j$) and the direct influence-related parameters, the GeoDetector classifies the interactions of factor pairs into five categories [70] (Figure 3). The value of q is calculated as follows [71]:

$$q = 1 - \frac{\sum_{h=1}^{l} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST},\ SSW = \sum_{h=1}^{l} N_h \sigma_h^2,\ SST = N\sigma^2 \quad (6)$$

For Factor Detector, q represents the direct influence (explanatory) power of the independent variable (X_i) on the dependent variable (Y_i) and is generally marked with q (X_i). For Interaction Detector, q represents the combined influence of different independent variables (X_i and X_j) acting together on the dependent variable (Y_i), generally marked with q ($X_i \cap X_j$). where h is the number of layers or categories of independent variables; N_h and N are the number of cities in layer h and study area, respectively; σ_h^2 and σ^2 are the variances of dependent variables in layer h and the study area, respectively; SSW is the within sum of squares of variances; and SST is the total sum of squares in the study area. According to the relationship of q ($X_i \cap X_j$) with the minimum direct influence value (Min (q (X_i), q (X_j)), the maximum value (Max (q (X_i)), q (X_j)), and the sum value (q (X_i) + q (X_j)) (Figure 4).

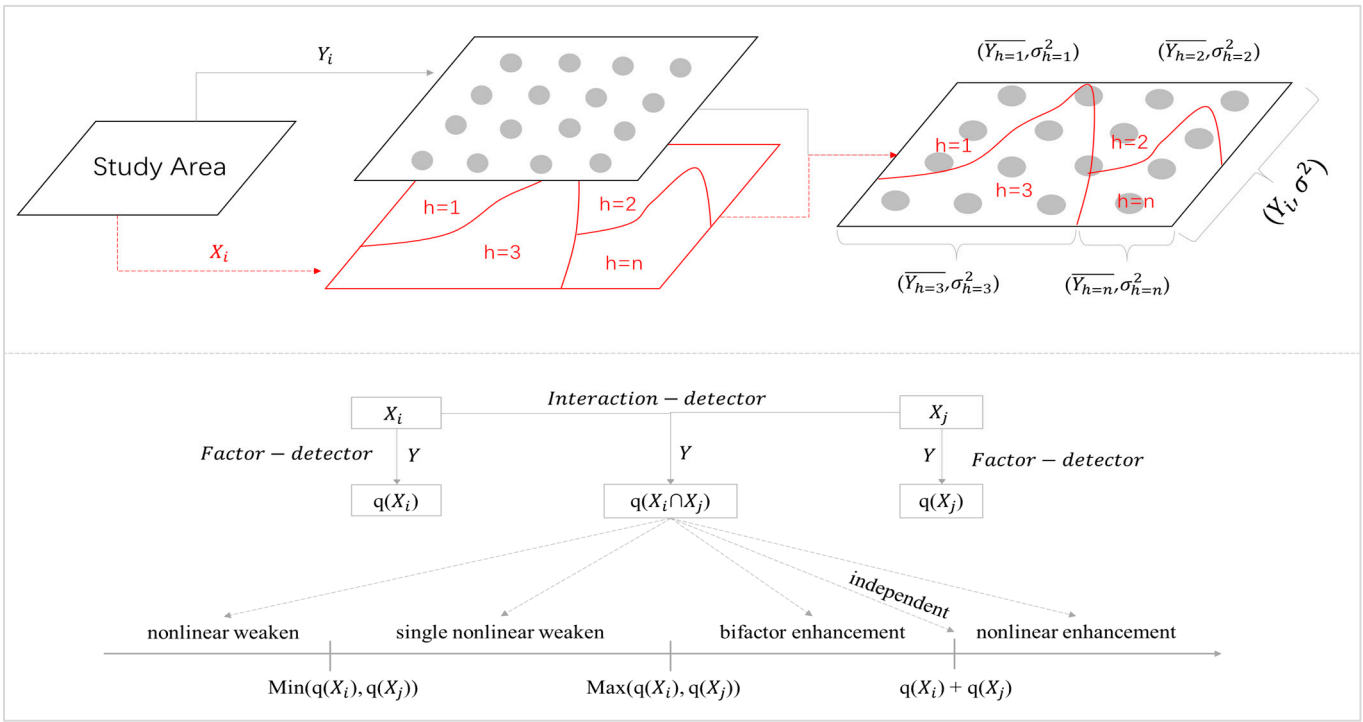


Figure 4. The factor and interaction detector analysis of ISCs based on GeoDetector.

This paper established a system of indicators for the analysis of ISC-driven mechanisms based on 3 dependent variables and 18 independent variables (Table 1). The dependent variables include $Y_1 \sim Y_3$, with evolution mode of all international students in China (EMAISC) used for analyzing the spatio-temporal dynamics of ISCs at the overall level, evolution mode of master's international students in China (EMMISC) and evolution mode of doctoral international students in China (EMDISC) used for analyzing the spatio-temporal dynamics of high-level international students. ISCs include all international students receiving academic and non-academic education. The former requires the attainment of Chinese advanced degrees and qualifications, including vocational schools, undergraduate degrees, master's degrees, and doctoral degrees. In contrast, the latter refers to all long-term and short-term international students who are not pursuing Chinese advanced degrees and qualifications for the purpose of study, including senior advanced

students, general advanced students, Chinese language students, and short-term visiting students. The dependent variable is the result of the analysis based on the BCG model. We assigned Star, Cow, Gazelle, and Dog values of 4, 3, 2, and 1, respectively, in the calculation.

Table 1. Indicator system for driving mechanism analysis.

Indicator	Abbreviation	Code	Meaning
Evolution Mode of All International Students in China	EMAISC	Y_1	Overall
Evolution Mode of Master's International Students in China	EMMISC	Y_2	High-Level
Evolution Mode of Doctoral International Students in China	EMDISC	Y_3	
Number of Students Enrolled (Person)	NSC	X_1	Educational Condition and Ability
Number of Higher Education Institutions (Unit)	NHEI	X_2	
Number of Educational Personnel (Person)	NEP	X_3	
Number of Teachers with Senior and Above Titles (Person)	NTSPT	X_4	
Educational Fund (Dollar)	EF	X_5	
Central Government Appropriation for Education (Dollar)	CGAE	X_6	
Local Government Appropriation for Education (Dollar)	LGAE	X_7	
Social Donation For Education Investment (Dollar)	SDEI	X_8	
Export International Trade (Dollar)	EIT	X_9	Globalization and Opening-up
Import International Trade (Dollar)	IIT	X_{10}	
Foreign Direct Investment (Dollar)	FDI	X_{11}	
Outward Foreign Direct Investment (Dollar)	OFDI	X_{12}	
International Tourism Revenue (Dollar)	ITR	X_{13}	
Number of International Sister City (Unit)	NISC	X_{14}	
Gross Domestic Product (Dollar)	GDP	X_{15}	Economic Development Strength
Added Value of Secondary Industry (Dollar)	AVSI	X_{16}	
Added Value of Tertiary Industry (Dollar)	AVTI	X_{17}	
Per Capita GDP (Dollar)	PCGDP	X_{18}	

According to the research experience, there are three considerations in selecting the independent variables:

First, the selection of independent variables should prioritize the educational condition and ability, which represents the attractiveness to ISCs in different provincial administrative regions during education internationalization. In this paper, we used indicators $X_1 \sim X_8$ for measurement, using number of students enrolled (NSC) to measure the impact of places and abilities, number of higher education institutions (NHEI) to measure the impact of the conditions of educational hardware, number of educational personnel (NEP) and number of teachers with senior and above titles (NTSPT) to measure the impact of the conditions of educational software, educational fund (EF) to measure the impact of scale effects of investment in education, central government appropriation for education (CGAE), local government appropriation for education (LGAE), and social donation for education investment (SDEI) to measure the impact of the structural effect of education investment [72].

Second, the impact of international partnerships in the internationalization of education is a major consideration in the selection of independent variables, especially the impact of globalization and opening-up of different provincial administrative regions. It represents the channel for information acquisition and relationship building when ISCs select a study destination. In this paper, we used indicators $X_9 \sim X_{14}$ for the measurement, using export international trade (EIT) and import international trade (IIT) to measure the impact of two-way international trade, foreign direct investment (FDI) and outward foreign direct investment (OFDI) to measure the impact of two-way international investment, international tourism revenue (ITR) to measure the impact of the international tourism market, and number of international sister cities (NISC) to measure the impact of international cooperation and exchange of cities [73,74].

Third, the selection of independent variables needs to additionally take into account the impact of the economic development strengths of different provincial administrations on the development of internationalization of education, which are considerable mediating

variables contributing to the arrival of international students. In this paper, we used indicators $X_{15} \sim X_{18}$ for the measurement, using gross domestic product (GDP) to measure the impact of economies of scale, added value of secondary industry (AVSI) and added value of tertiary industry (AVTI) to measure the impact of structural effects on the economy, and per capita GDP (PCGDP) to measure the impact of the economic development stage [75,76].

The ISC data were based on the Concise Statistics of International Students in China publicly released by the Department of International Cooperation and Exchanges of the Ministry of Education of China. There was no master's or doctoral student in Qinghai in 2013, but since the denominator in the calculations cannot be zero, we assigned the value to 1. Most of regional independent variables came from the China Statistical Yearbook and the Educational Statistics Yearbook of China published by the National Bureau of Statistics of China and the Department of Development Planning of the Ministry of Education, respectively, with small portion from the provincial statistical yearbooks and statistical bulletins published by the provincial bureau of statistics. In addition, OFDI data came from the Statistical Bulletin of China's Outward Foreign Direct Investment jointly published by the Ministry of Commerce, the National Bureau of Statistics, and the State Administration of Foreign Exchange; and NISC data came from the database of the Chinese People Association for Friendship with Foreign Countries. The base period of this paper started from 2013 when the Chinese government proposed the "Belt and Road" initiative to 2018 when the pandemic COVID-19 broke out. The pandemic led to great changes in the global international student market and in the study-abroad policies, programs, and planning across the world [77], and pushed China's acceptance of international students into a state of "stagnation" or even "recession" [78]. Given that, the inclusion of 2019 and later data in the study would jeopardize the accuracy of the results of this paper and make it impossible to better reflect the real situation of ISC development and change in the context of the "Belt and Road" Initiative.

2.3.3. Management Strategies: Dynamics and Driving Coupled Analysis Model

This paper overlaid the results of the analysis of spatio-temporal dynamics and driving mechanisms and proposed dynamics and driving coupled analysis model (DDCAM) as a tool for ISC management strategy and policy design. DDCAM is a new classification method created according to the principles of the three-dimensional Cartesian coordinate system, with the aim of overlaying and integrating the results of analyses in different dimensions in a generalized way. In the application it is necessary to select three indicators to represent the three dimensions of the coordinate system. Using the median or mean as a threshold allows the study objects to be categorized into 8 types, and based on the calculation of the three-dimensional index for each area it is possible to identify their position in the coordinate system. Since the BCG matrix is essentially a classification mindset based on a two-dimensional coordinate system, DDCAM can be viewed as an upgrade to it from two to three dimensions. We can obtain the driving forces by inverse operation of GeoDetector output results in the following steps: first, standardize the independent variables according to Equation (7); second, calculate the weight of each indicator according to Equation (8); third, calculate the weighted sum of all the influencing factors of each provincial administrative region according to Equation (9) to characterize the driving force of them on ISC; fourth, classify the driving force into two grades of HIGH and LOW by taking the median as the threshold value; and fifth, overlay the calculations from step 4 with the results of the BCG analysis to analyze the results, thus dividing the study area into eight spatial zonings, which lays the foundation for management strategies and policy design (Figure 5).

$$X_{ij}^{'} = \frac{Max_i - X_{ij}}{Max_i - Min_i} \tag{7}$$

$$W_i = \frac{\mathrm{AVG}(\mathrm{q}(X_i \cap X_j))}{\sum_{i=1}^{n} \mathrm{AVG}(\mathrm{q}(X_i \cap X_j))} \tag{8}$$

$$F_j = \sum_{i=1}^{n} W_i X_{ij}^{'} \quad (9)$$

where $X_{ij}^{'}$ is the standardized value of the i-th independent variable in the j-th provincial administrative region, Max_i and Min_i are the maximum and minimum values of the i-th independent variable, and i and j are the serial numbers of the independent variable and the provincial administrative region, $i = 1, 2, 3, \ldots\ldots, n$; $j = 1, 2, 3, \ldots\ldots, m$. W_i represents the weight of the i-th independent variable, $\mathrm{AVG}\left(\mathrm{q}\left(X_i \cap X_j\right)\right)$ represents the average of the interaction effect of the i-th independent variable with all independent variables, and F_j represents the driving force of the j-th provincial administration.

Driving Force					
	High	Internal Governance Zone	Important Development Zone	Important Retention Zone	Important Demonstration Zone
	Low	External Assistance Zone	General Development Zone	General Retention Zone	General Demonstration Zone
		Dog	Gazelle	Cow	Star
		Spatiotemporal Dynamics			

Figure 5. The dynamics and driving coupled analysis model of ISC.

3. Results

3.1. Spatio-Temporal Dynamics Analysis

3.1.1. All Students

In terms of Relative Share, Beijing ranked first in receiving ISCs in 2018, while Tibet ranked last. The coefficient of variation was 1.17, much larger than 0.36, indicating strong spatial heterogeneity in the geographic distribution of ISCs at the provincial scale in China. According to the spatial clustering analysis, except for Yunnan and Hubei, the high-value areas were distributed in the coastal provinces, the medium-value areas were mostly concentrated in the Guangdong-Hong Kong-Macao Greater Bay Area and the fringes of the Pan-Pearl River Delta (PRD) continent, and the low-value areas were mainly in north and west China, indicating that the ISCs were distributed in a gradient from the east coast to the central and western parts of the country. Moran's I of 0.10 (z = 1.79, $p < 0.05$) indicated a significant positive spatial correlation in the geographic distribution of ISCs. The analysis showed that the hot spots were clustered in the east, the cold spots were in the west, the sub-hot spots tend to gather in the northwest, and the sub-cold spots were mostly in the south, especially in the southwestern Bohai Bay region (Figure 6).

In terms of Growth Rate: Shanxi Province saw the fastest growth from 2013 to 2018, followed by Jiangsu, Henan, Hainan, Sichuan, Guizhou, Yunnan, and Chongqing, while negative growth was found in Fujian, Tibet, and Qinghai with the largest shrink in Xinjiang. The coefficient of variation was 1.89, indicating significant spatial heterogeneity in ISC growth at the provincial scale in China. According to the spatial clustering analysis, high-value areas developed into two agglomeration centers in the Pearl River Delta and the Yunnan-Guizhou Plateau, with the medium-value areas distributed between the two centers and their periphery, and the low-value areas clustered in the border areas in the northwest and northeast. Moran's I of 0.01 (z = 0.72, $p > 0.05$) indicated that the ISC growth had only a weak positive spatial correlation and was not statistically significant. The analysis showed that the hot spots were clustered in the Loess Plateau and its surrounding

regions, the cold spots were mostly in the northwestern and northeastern regions along the border, the sub-hotspots were mostly in Beijing-Tianjin-Hebei Region and its periphery in northern China, and the sub-cold spots were in Guangdong Province and its peripheral regions (Figure 7).

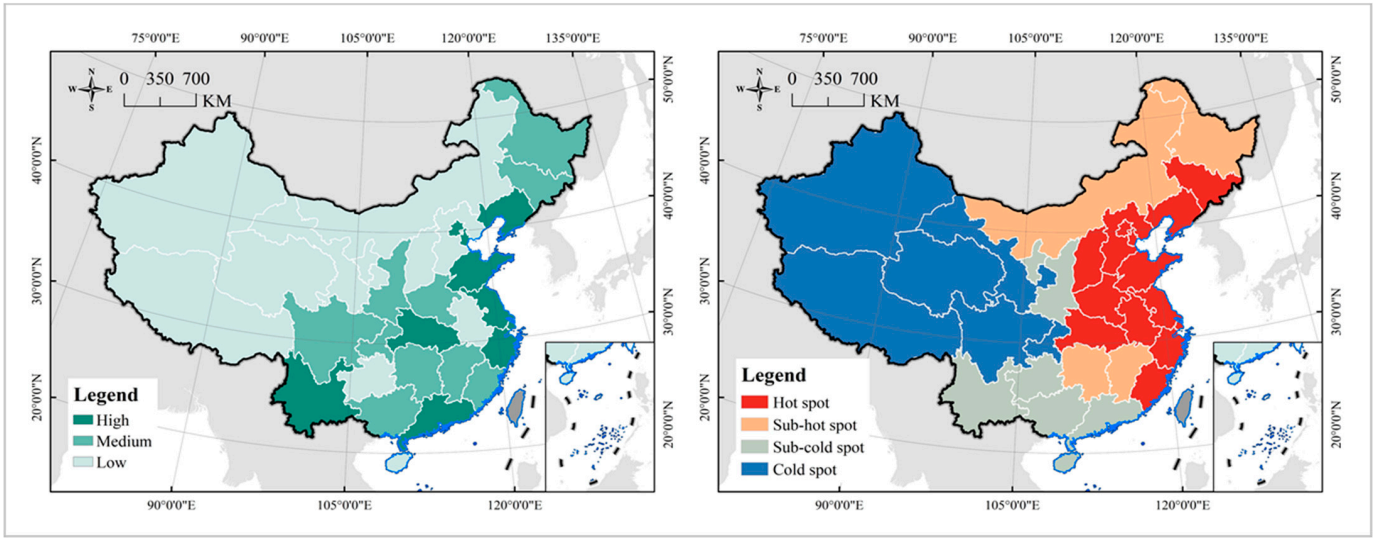


Figure 6. The relative share analysis of all students.

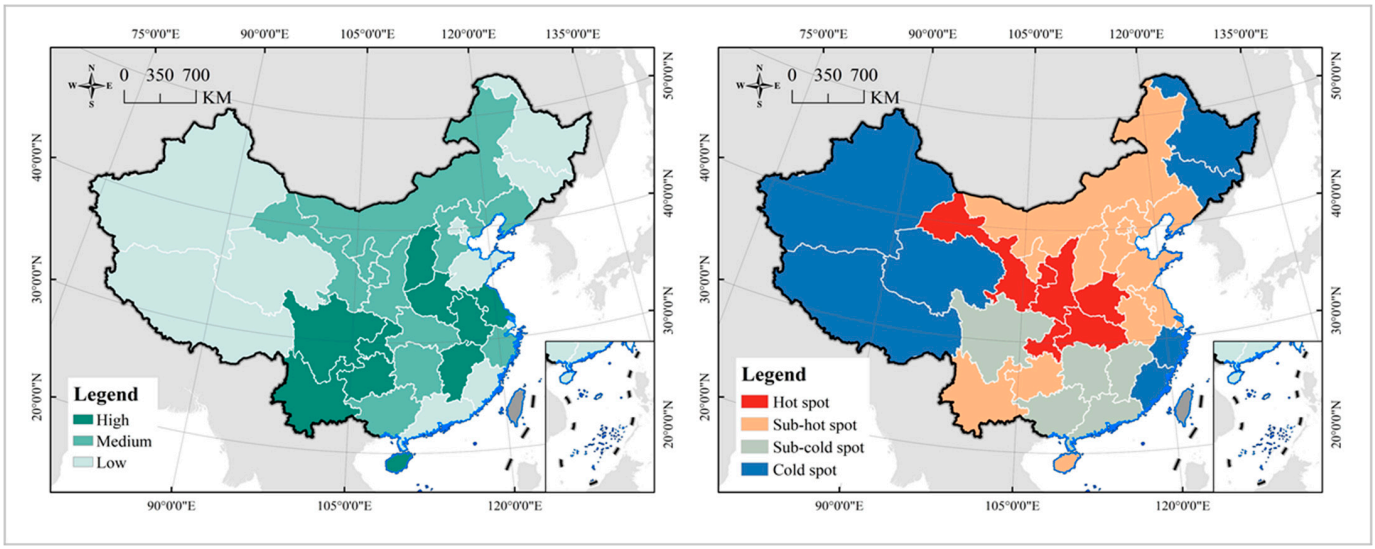


Figure 7. The growth rate analysis of all students.

According to the BCG analysis, the median relative share in 2018 and the median growth rate from 2013 to 2018 were 11.80% and 53.00%, respectively, and we categorized the ISC temporal dynamics into four types using them as thresholds. Most of the star-type areas were clustered in the Yunnan-Guizhou Plateau and Loess Plateau regions in bands, the cow-type areas were relatively concentrated in the southern coastal region, the gazelle-type areas were clustered in the central region, and the dog-type areas were clustered in the northwestern region. In general, the spatio-temporal dynamics of ISCs in Jiangsu, Zhejiang, Sichuan, Chongqing, Hubei, Shaanxi, and other traditional higher education developed regions were in a good state; the northeast and southwest border areas showed a good momentum of development momentum; Liaoning and Yunnan were in an ideal state, while Guangxi and Heilongjiang encountered some bottlenecks and obstacles. Moran's I of 0.18 ($z = 2.59$, $p < 0.05$) indicated that the spatio-temporal dynamics of ISCs had a significant

positive spatial correlation. The analysis showed that the hot spots were clustered along the Yangtze River Economic Zone, the cold spots were in the northwest, the sub-hot spots were distributed in the fringe areas north and south of the hot spots, and the sub-cold spots were clustered and distributed in north China (Figure 8).

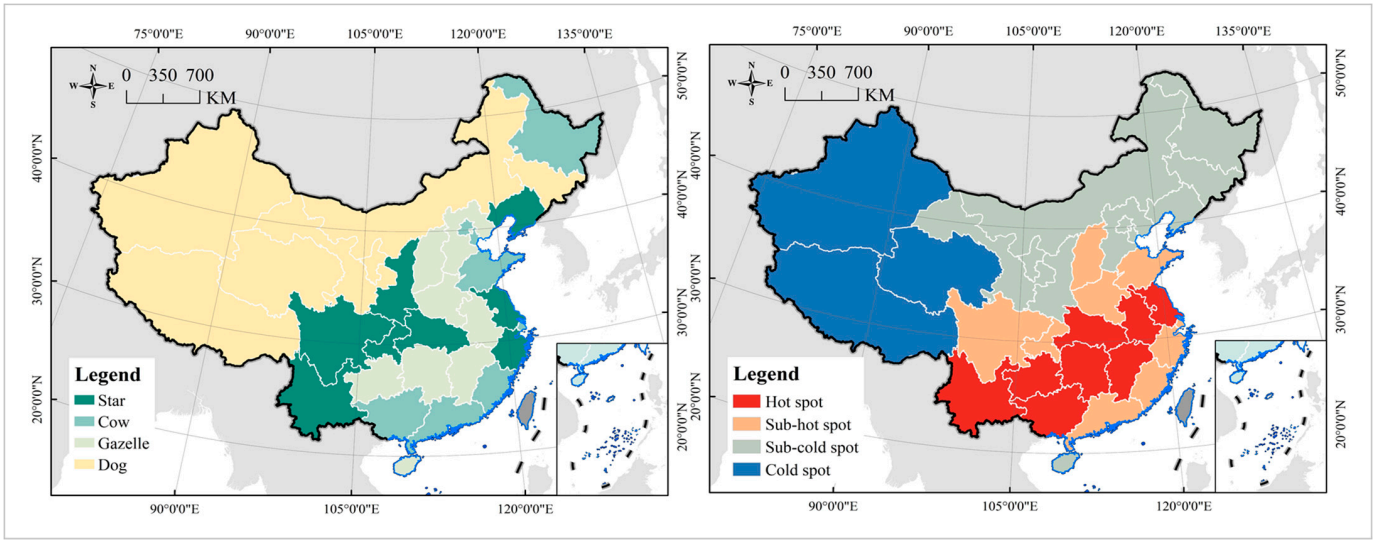


Figure 8. The spatio-temporal dynamics analysis of all students.

3.1.2. Master's Students

In terms of Relative Share, Beijing ranked first in receiving master's students in 2018, while Qinghai ranked last. The coefficient of variation was 1.28, indicating strong spatial heterogeneity in the geographic distribution of master's students at the provincial scale in China. According to the spatial clustering analysis, high-value areas were scattered in traditionally developed regions of higher education such as Jiangsu, Zhejiang, Ningbo, Heilongjiang, Hubei, Shaanxi and Sichuan; medium-value areas were distributed in the periphery of high-value areas and relatively concentrated in the Pearl River Delta and northeast China; and low-value areas were mostly distributed in the Yellow River Basin, with two centers formed in northwest China and the Central Plains. Moran's I of 0.07 ($z = 1.61$, $p < 0.05$) indicated a significant positive spatial correlation in the geographic distribution of master's students. The analysis showed that hot spots were clustered and distributed in the southwest and northwest regions, cold spots were clustered in Bohai Bay and the Yellow River estuary region, most of the sub-hotspots were clustered in the north of China and the north of Guangdong, and the sub-cold spots were clustered and distributed in the central plains and its surrounding regions (Figure 9).

In terms of Growth Rate: Shanxi Province had the fastest growth rate from 2013 to 2018, followed by Guizhou, Shaanxi, Shanxi, and Ningxia; while Inner Mongolia and Xinjiang had a slow growth rate, with shrink found only in Guangxi. The coefficient of variation was 2.94, indicating strong spatial heterogeneity in the growth rate of master's students at the provincial scale in China. According to the spatial clustering analysis, high-value areas were clustered in the upstream of the Yellow River Basin and the downstream of the Yangtze River Basin, medium-value areas were mostly clustered in the downstream of the Yellow River Basin and the Bohai Rim region, and low-value areas were mostly clustered in northern China and the Pearl River Delta. Moran's I of -0.09 ($z = -1.66$, $p < 0.05$) indicated a negative spatial correlation in the growth rate of master's students. The analysis showed that the hot spots were clustered and distributed in the northwest region, most of the sub-hotspots were clustered in north China with Beijing-Tianjin-Hebei as the center, the cold spots were clustered in bands, and the sub-hotspots grew into three clusters based in the Pearl River Delta (PRD), Yangtze River Delta (YRD), and Guanzhong Plain (Figure 10).

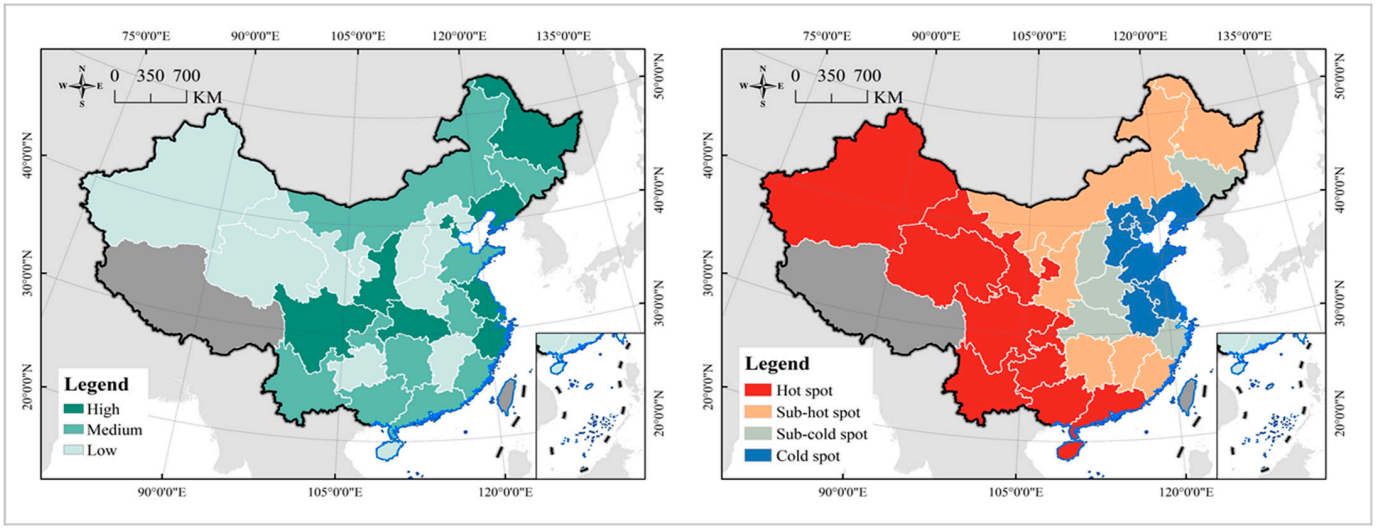


Figure 9. The relative share analysis of master's students.

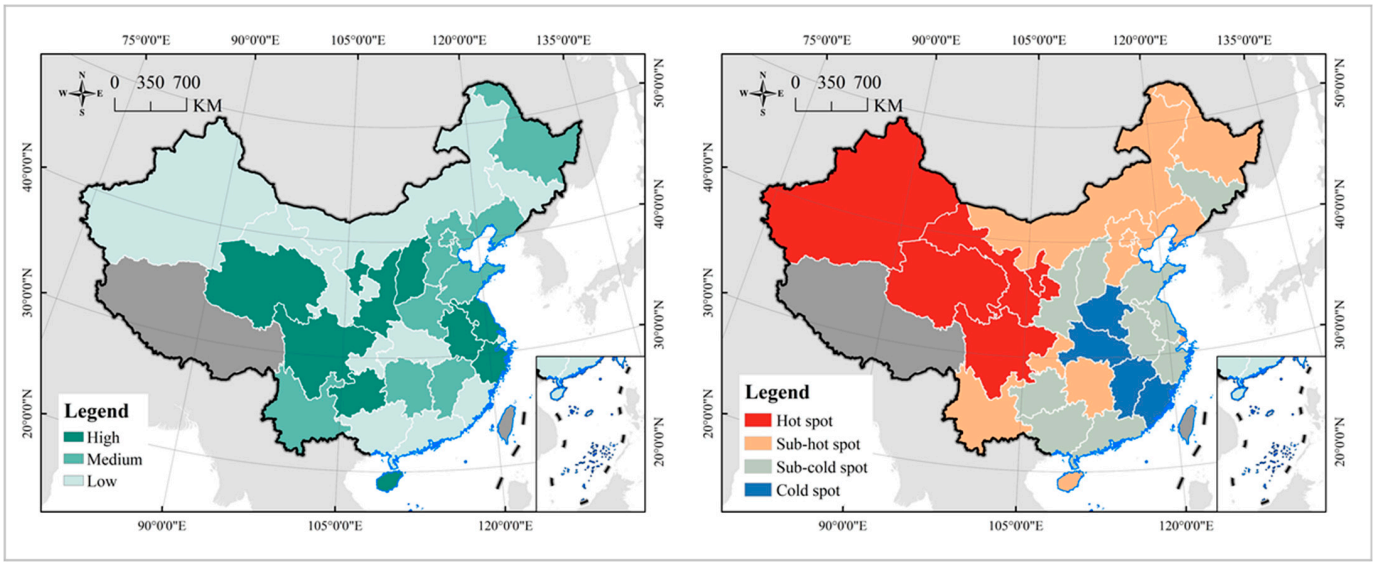


Figure 10. The growth rate analysis of master's students.

According to the BCG analysis, the median relative share in 2018 and the median growth rate from 2013 to 2018 were 10.06% and 98.48%, respectively, and we categorized the spatio-temporal dynamics of master's students into four types using them as thresholds. The star-types areas grew into two agglomerative zones in Shandong-Zhejiang in the east and Shaanxi-Yunnan in the west, most of the cow-type areas were clustered in the north-eastern China–Russia border region, most of the gazelle-type areas were in the central region, and most of the dog-type areas were in north China. Moran's I of 0.03 ($z = 0.84$, $p > 0.05$) indicated a weak positive spatio-temporal correlation between the spatio-temporal dynamics of master's students, but not statistically significant. The analysis showed that the hot spots were clustered along the eastern coast in bands, the sub-hot spots were distributed in their periphery and extended southwestward, the cold spots were scattered in distribution, and most of the sub-cold spots were clustered in the Loess Plateau and its periphery (Figure 11).

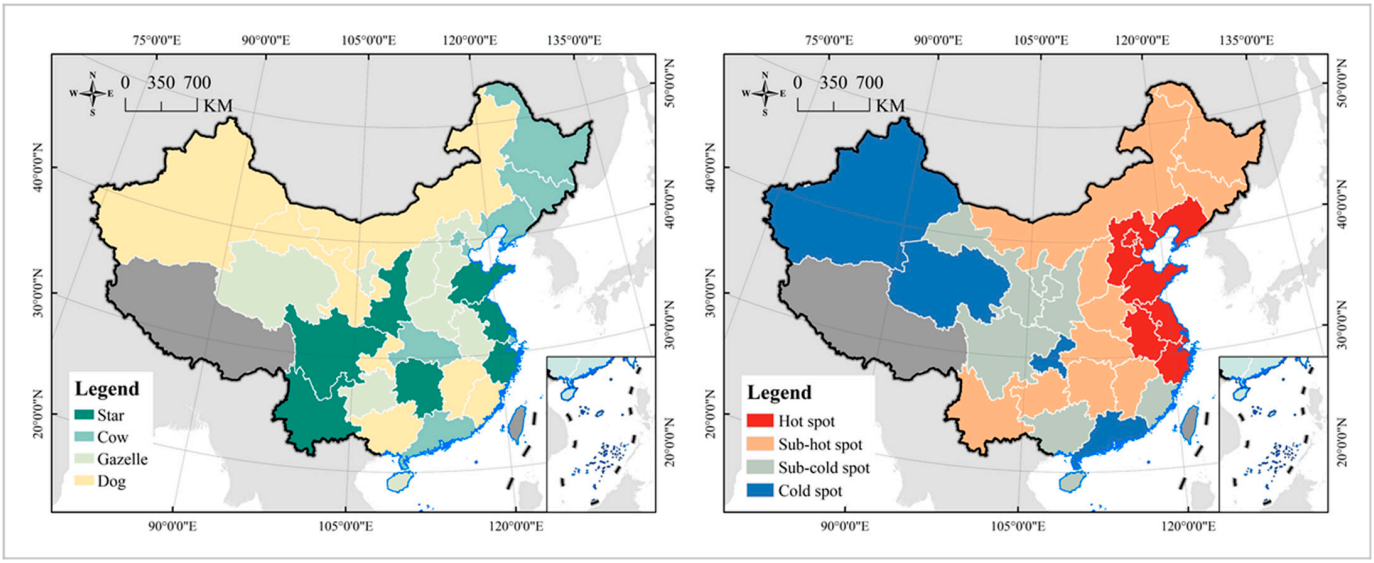


Figure 11. The spatio-temporal dynamics analysis of master's students.

3.1.3. Doctoral Students

In terms of Relative Share, Beijing ranked first in receiving doctoral students in 2018, while Qinghai ranked last. The coefficient of variation was 1.44, indicating strong spatial heterogeneity in the geographic distribution of doctoral students at the provincial scale in China. According to the spatial clustering analysis, most of the doctoral students were clustered in the coastal and Yangtze River Basin, which high-value areas concentrated in the three urban agglomerations of the Yangtze River Delta, the middle reaches of the Yangtze River, and Chengdu-Chongqing, medium-value areas distributed in their periphery, and low-value areas mainly concentrated in north China and the Beibu Gulf. Moran's I of 0.05 ($z = 1.26$, $p < 0.10$) indicated a positive spatial correlation in the geographic distribution of doctoral students, but at a relatively loose level of significance. The analysis showed that the hot spots were clustered in the eastern region of the Yangtze River and the Yellow River estuary as well as the Bohai Bay region, while the cold spots were distributed in the northwestern–southwestern region in bands, and the sub-hot spots and sub-cold spots covered a small geographic area (Figure 12).

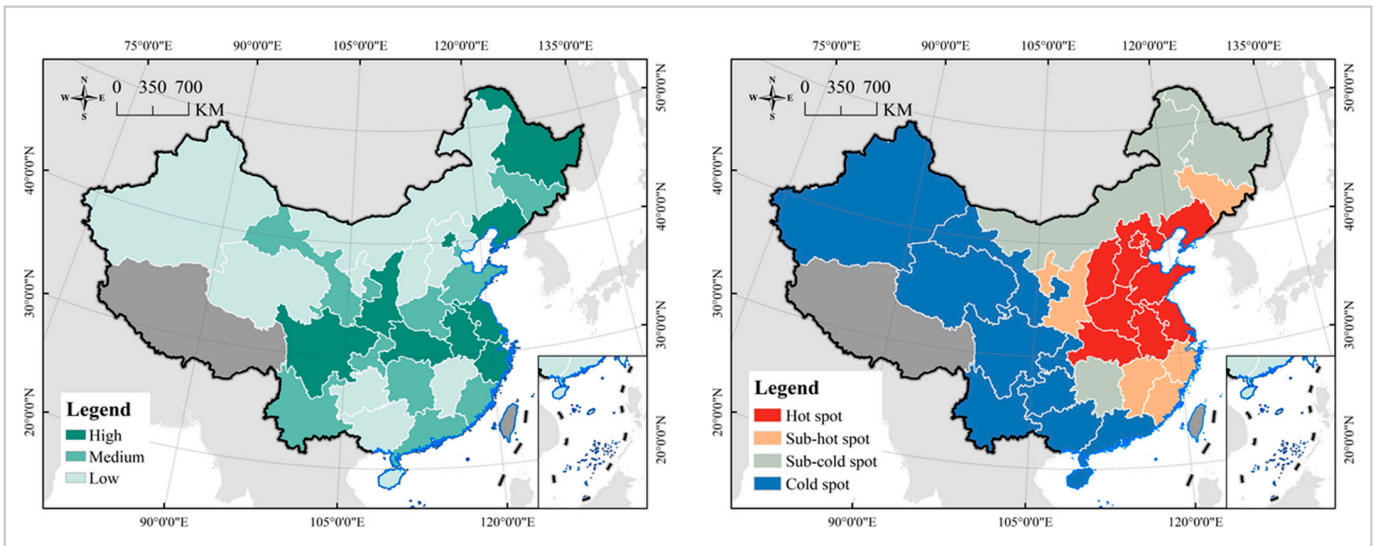


Figure 12. The relative share analysis of doctoral students.

In terms of Growth Rate, Province experienced the fastest growth from 2013 to 2018, followed by Henan, Jiangxi, Guizhou, Hebei, Anhui, and Guangxi; while Liaoning, Jilin, and Hunan had slower growth, with the slowest growth found in Inner Mongolia. The coefficient of variation was 1.85, indicating significant spatial heterogeneity in ISC growth at the provincial scale in China. According to the spatial clustering analysis, high-value areas developed into two agglomeration centers in the middle reaches of the Yellow River and southwest China, medium-value areas were distributed in the northwest, and low-value areas developed into two agglomerations in northeast and south China. Moran's I of −0.06 ($z = -0.52$, $p > 0.05$) indicated a weak negative spatial correlation of the growth of doctoral students, but not statistically significant. The analysis showed that Gansu, Inner Mongolia, Chongqing, and Hunan were hot spots; the cold spots formed three agglomeration clusters in the west, northeast, and east coast, and most of the sub-hot spots were clustered in Central and North China, and the sub-cold spots were relatively clustered in the south of the Five Ridges (Figure 13).

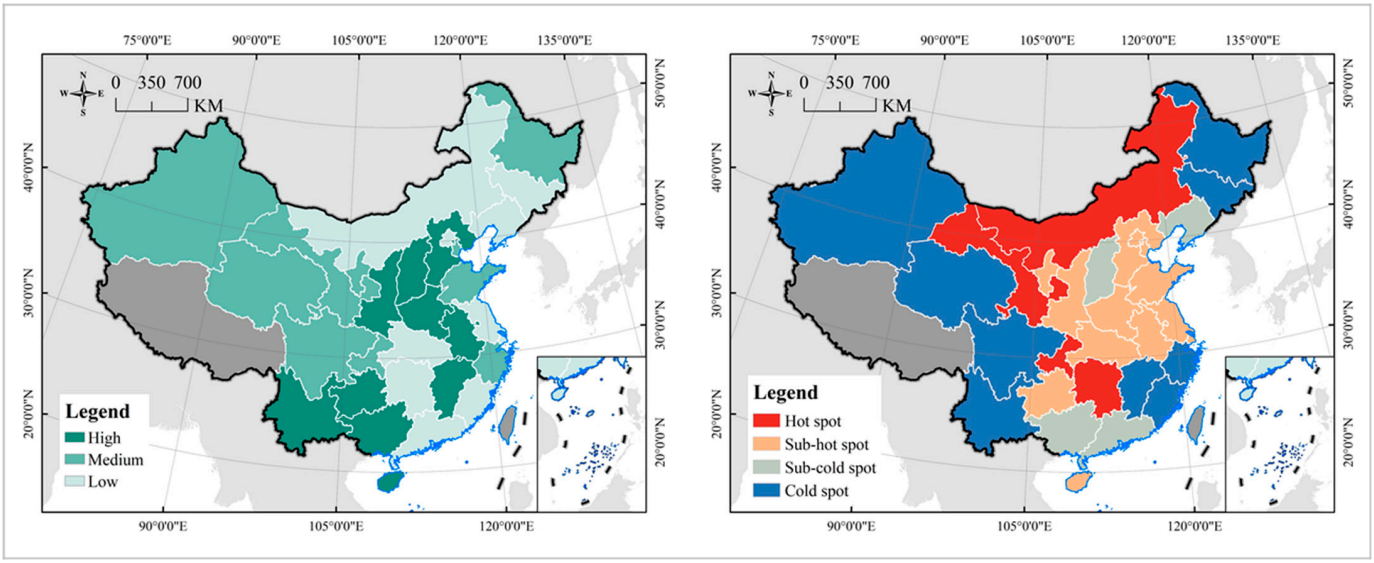


Figure 13. The growth rate analysis of doctoral students.

According to the BCG analysis, the median relative share in 2018 and the median growth rate from 2013 to 2018 were 7.48% and 916.07%, respectively, and we categorized the ISC temporal dynamics into four types using them as thresholds. Sichuan, Chongqing, Shaanxi, Shandong, and Anhui were star-type areas, most of the cow-type areas were clustered in bands along the eastern coast and in the middle reaches of the Yangtze River, most of the gazelle-type areas were distributed in the Yellow River Basin and the south-western region, and the dog-type regions were clustered in northwest China. Moran's I of 0.04 ($z = 0.95$, $p > 0.05$) indicated a weak positive spatio-temporal correlation in the spatio-temporal dynamics of doctoral students. The analysis showed that the hot spots were clustered in the middle and lower reaches of the Yangtze River Basin, with the sub-hot spots extending on its periphery towards the Yunnan-Guizhou Plateau in the southwest and the Loess Plateau in the northwest, the sub-cold spots mostly clustered in Bohai Bay, and the cold spots distributed in the north (Figure 14).

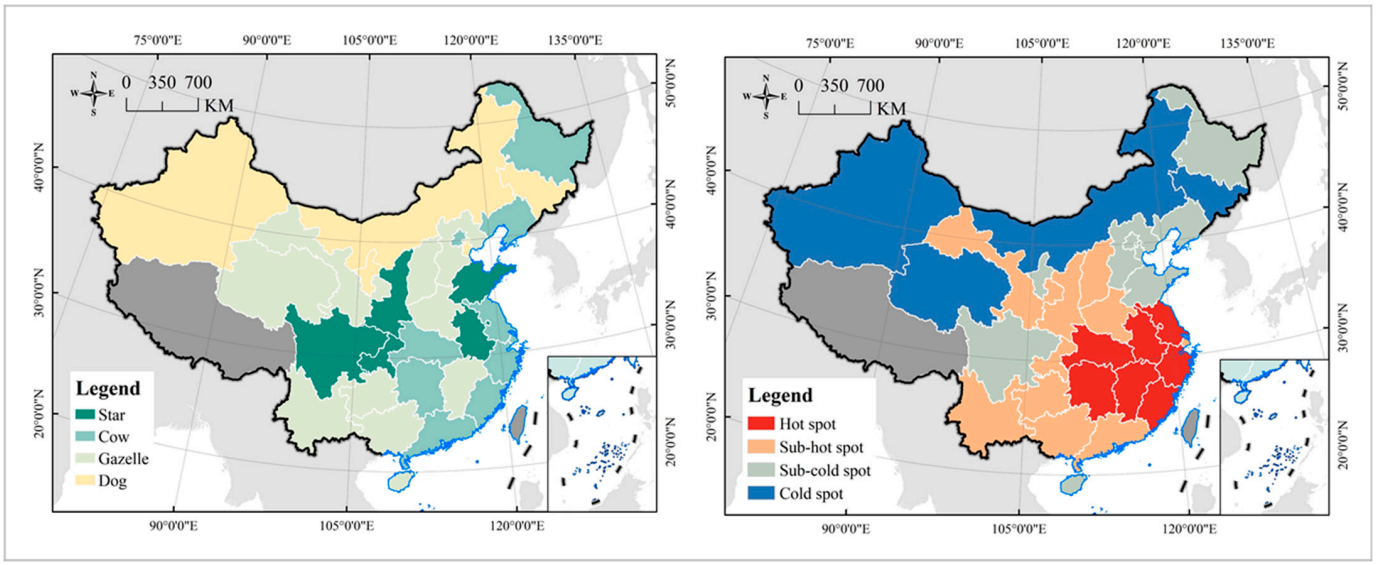


Figure 14. The spatio-temporal dynamics analysis of doctoral students.

Both master's students and doctoral students showed the same characteristics in geographic distribution. The geographic patterns of relative share, growth rate, and spatio-temporal dynamics of international students were characterized by strong spatial heterogeneity and agglomeration, with the coefficients of variation much larger than 0.36. In addition, their geographic distributions were also characterized by some spatial correlation and dependence, contributing to the spatial growth pole spillover effect and the spatial depression effect. Moreover, there were also many differences in the geographic distribution of master's students and doctoral students. In relative share, the hot spots of doctoral students were clustered in the eastern seaboard, while for the master's students, on the contrary, the hot spots were clustered in the west with a much larger geographic coverage than that of doctoral students. As for the growth rate, the hot spots of master's students were clustered in the northwest, while the hot spots of doctoral students were scattered in distribution with no clear agglomeration. By spatio-temporal dynamics, the hot spots of master's students were concentrated in the east coast in the form of a belt, forming a "spatial agglomeration belt" with gradient changes in the east, middle and west; the hot spots of doctoral students were in the middle and lower reaches of the Yangtze River Economic Belt in clusters and extended to the southwest and northwest in the form of fingers. Of note is that the growth rate for both doctoral and master's students showed a spatial negative correlation, while all the other parameters showed a positive spatial correlation, requiring consideration of their differences in policy design.

3.2. Driving Mechanism Analysis

3.2.1. Direct Influence

NSC, SDEI, and EIT had a strong direct driving force on EMAISC, but a weak force on EMDISC, with no statistically significant influence on EMMISC. CGAE and OFDI had a strong direct driving force on EMAISC, but a weak force on EMMISC, with a loosely statistically significant influence on EMDISC only. NHEI, FDI, ITR, NISC, GDP, AVSI, and AVTI had a strong direct driving force on EMDISC and EMAISC, but a relatively weak force on EMMISC. NEP, NTSPT, IIT, and LGAE had essentially the same influence on EMAISC, EMMISC and EMDISC, and LGAE had a relatively weak direct driving force. EF had a high and essentially equal influence on EMAISC and EMDISC, while a weak influence on EMMISC. PCGDP had a weak and not statistically significant influence on EMMISC and EMDISC, and had a relatively strong but loosely statistically significant influence on EMAISC (Table 2).

Table 2. Factor detection analysis results of ISC.

Code	Abbreviation	EMAISC (Y_1)		EMMISC (Y_2)		EMDISC (Y_3)	
		q	p	q	p	q	p
X_1	NSC	0.48	0.01	0.22	0.14	0.36	0.03
X_2	NHEI	0.47	0.03	0.16	0.05	0.55	0.00
X_3	NEP	0.47	0.02	0.49	0.01	0.49	0.03
X_4	NTSPT	0.49	0.00	0.50	0.02	0.53	0.01
X_5	EF	0.50	0.02	0.21	0.03	0.53	0.01
X_6	CGAE	0.36	0.01	0.28	0.04	0.35	0.07
X_7	LGAE	0.24	0.04	0.28	0.04	0.33	0.05
X_8	SDEI	0.42	0.05	0.05	0.28	0.27	0.01
X_9	EIT	0.47	0.03	0.08	0.17	0.36	0.01
X_{10}	IIT	0.69	0.00	0.52	0.02	0.50	0.01
X_{11}	FDI	0.58	0.00	0.32	0.05	0.65	0.00
X_{12}	OFDI	0.46	0.01	0.16	0.05	0.15	0.06
X_{13}	ITR	0.66	0.00	0.16	0.05	0.48	0.03
X_{14}	NISC	0.45	0.02	0.21	0.03	0.49	0.03
X_{15}	GDP	0.57	0.00	0.36	0.03	0.52	0.01
X_{16}	AVSI	0.45	0.04	0.16	0.05	0.40	0.04
X_{17}	AVTI	0.51	0.00	0.34	0.01	0.48	0.03
X_{18}	PCGDP	0.19	0.09	0.08	0.17	0.06	0.22

In summary, IIT, ITR, FDI, GDP, AVTI, and EF had a strong direct influence on EMAISC; IIT and NTSPT had a strong direct influence on EMMISC; FDI, NHEI, NTSPT, EF, GDP, and IIT had a strong direct influence on EMDISC; all their direct driving forces were greater than 0.5 as key factors. PCGDP had a weak direct influence on EMAISC; NHEI, OFDI, ITR, AVSI, EIT, PCGDP, and SDEI had a weak direct influence on EMMISC; OFDI and PCGDP had a weak direct influence on EMDISC; all their direct driving forces were less than 0.2, mostly with no statistical significance as auxiliary factors. The other factors had a direct driving force ranging from 0.2 to 0.5, mostly statistically significant ($p < 0.05$) as importance factors with a considerable direct influence.

3.2.2. Interaction Effect

According to their interaction relationship, there were significant synergistic effects between different factors. Most of the factor pairs showed bifactor enhancement, while a few showed nonlinear enhancement. For EMAISC, PCGDP showed nonlinear enhancement with a large number of factors, including NHEI, EF, FDI, NISC, GDP, and AVSI. For EMMISC, NSC, SDEI, and PCGDP showed nonlinear enhancement with a large number of factors, for example, the relationship of NSC with SDEI, LGAE, NEP, NTSPT, EF, CGAE, IIT, and AVTI. For EMDISC, PCGDP showed nonlinear enhancement with other factors, including EF, CGAE, LGAE, SDEI, IIT, ITR, NISC, GDP, and AVTI (Tables 3–5).

As for interaction intensity, there were many super-interacting factor pairs, especially a large number of factor pairs with interaction impacts exceeding 0.8 or even 0.9 for EMAISC and EMDISC. For EMAISC, 47 super factor pairs emerged, accounting for 30.72% of the total, with $X_2 \cap X_9$ (NHEI and EIT), $X_{10} \cap X_2$ (IIT and NHEI), $X_{11} \cap X_8$ (FDI and SDEI), $X_{11} \cap X_9$ (FDI and EIT), and $X_{13} \cap X_9$ (ITR and EIT) having an interaction influence of more than 0.9. For EMMISC, there were less super factor pairs, only $X_{11} \cap X_3$ (FDI and NEP) and $X_{11} \cap X_4$ (FDI and NTSPT). For EMDISC, 35 super factor pairs emerged, accounting for 22.88%. Compared with EMAISC, EMDISC gave rise to less super factor pairs, but seeing an increasing number of super factor pairs with an interaction influence of more than 0.9, including, $X_1 \cap X_{11}$ (NSC and FDI), $X_{11} \cap X_2$ (FDI and NHEI), $X_{13} \cap X_2$ (ITR and NHEI), $X_{11} \cap X_3$ (FDI and NEP), $X_{11} \cap X_4$ (FDI and NTSPT), $X_4 \cap X_{13}$ (NTSPT and ITR), $X_{13} \cap X_5$ (ITR and EF), $X_{11} \cap X_{13}$ (FDI and ITR), $X_{11} \cap X_{14}$ (FDI and NISC), $X_{15} \cap X_{11}$ (GDP and FDI), and $X_{13} \cap X_{16}$ (ITR and AVSI) (Tables 3–5).

Table 3. Interaction detection analysis results of EMAISC (all students).

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_2	0.66																
X_3	0.60	0.71															
X_4	0.65	0.61	0.64														
X_5	0.71	0.80	0.79	0.82													
X_6	0.63	0.55	0.65	0.60	0.58												
X_7	0.63	0.53	0.63	0.61	0.53	0.42											
X_8	0.83	0.87	0.82	0.80	0.82	0.64	0.55										
X_9	0.75	0.90	0.80	0.69	0.75	0.51	0.57	0.78									
X_{10}	0.80	0.97	0.83	0.80	0.81	0.76	0.79	0.85	0.82								
X_{11}	0.76	0.82	0.80	0.73	0.85	0.76	0.78	0.92	0.96	0.84							
X_{12}	0.75	0.73	0.80	0.71	0.70	0.55	0.57	0.66	0.58	0.79	0.76						
X_{13}	0.85	0.80	0.83	0.84	0.85	0.72	0.72	0.88	0.93	0.86	0.83	0.79					
X_{14}	0.78	0.71	0.72	0.71	0.70	0.52	0.57	0.84	0.71	0.76	0.85	0.76	0.75				
X_{15}	0.72	0.79	0.73	0.64	0.81	0.73	0.73	0.81	0.82	0.88	0.77	0.79	0.88	0.80			
X_{16}	0.68	0.68	0.81	0.75	0.74	0.55	0.55	0.74	0.81	0.87	0.67	0.72	0.80	0.76	0.66		
X_{17}	0.74	0.72	0.73	0.67	0.69	0.68	0.66	0.68	0.76	0.73	0.70	0.62	0.82	0.67	0.66	0.63	
X_{18}	0.68	0.77	0.64	0.70	0.78	0.50	0.40	0.53	0.62	0.76	0.81	0.61	0.77	0.69	0.80	0.76	0.71

Table 4. Interaction detection analysis results of EMMISC (master's students).

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_2	0.31																
X_3	0.63	0.55															
X_4	0.62	0.54	0.71														
X_5	0.32	0.28	0.53	0.58													
X_6	0.36	0.35	0.64	0.69	0.31												
X_7	0.41	0.38	0.70	0.76	0.34	0.35											
X_8	0.44	0.19	0.59	0.70	0.39	0.43	0.40										
X_9	0.40	0.19	0.55	0.59	0.25	0.38	0.39	0.12									
X_{10}	0.68	0.57	0.77	0.79	0.64	0.70	0.81	0.64	0.61								
X_{11}	0.72	0.46	0.84	0.81	0.44	0.58	0.53	0.40	0.47	0.62							
X_{12}	0.35	0.23	0.54	0.58	0.28	0.35	0.35	0.23	0.19	0.55	0.34						
X_{13}	0.39	0.26	0.57	0.66	0.28	0.46	0.42	0.21	0.27	0.67	0.42	0.27					
X_{14}	0.40	0.28	0.60	0.57	0.33	0.37	0.39	0.26	0.25	0.57	0.50	0.28	0.28				
X_{15}	0.53	0.41	0.63	0.76	0.42	0.60	0.62	0.42	0.46	0.79	0.56	0.50	0.42	0.44			
X_{16}	0.34	0.21	0.51	0.54	0.28	0.35	0.38	0.19	0.19	0.57	0.46	0.23	0.26	0.32	0.41		
X_{17}	0.51	0.37	0.61	0.66	0.46	0.52	0.61	0.71	0.38	0.66	0.59	0.37	0.50	0.39	0.46	0.37	
X_{18}	0.43	0.24	0.56	0.58	0.33	0.50	0.45	0.16	0.13	0.60	0.40	0.23	0.20	0.28	0.44	0.24	0.39

Table 5. Interaction detection analysis results of EMDISC (doctoral students).

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_2	0.62																
X_3	0.55	0.71															
X_4	0.60	0.70	0.61														
X_5	0.69	0.65	0.80	0.78													
X_6	0.65	0.61	0.81	0.82	0.59												
X_7	0.46	0.67	0.65	0.79	0.65	0.49											
X_8	0.57	0.63	0.56	0.64	0.63	0.51	0.43										
X_9	0.61	0.66	0.67	0.76	0.67	0.55	0.48	0.39									
X_{10}	0.78	0.78	0.83	0.75	0.84	0.74	0.86	0.64	0.65								
X_{11}	0.91	0.92	0.94	0.96	0.89	0.89	0.89	0.77	0.76	0.82							
X_{12}	0.44	0.57	0.61	0.66	0.60	0.42	0.44	0.34	0.41	0.60	0.67						
X_{13}	0.77	0.92	0.87	0.92	0.91	0.85	0.76	0.73	0.76	0.73	0.94	0.63					
X_{14}	0.73	0.75	0.86	0.81	0.86	0.63	0.66	0.73	0.81	0.84	0.96	0.61	0.86				
X_{15}	0.63	0.67	0.64	0.74	0.70	0.67	0.63	0.57	0.61	0.79	0.94	0.57	0.77	0.82			
X_{16}	0.65	0.70	0.70	0.74	0.61	0.69	0.72	0.52	0.63	0.71	0.75	0.49	0.91	0.73	0.73		
X_{17}	0.70	0.65	0.83	0.76	0.73	0.68	0.88	0.63	0.56	0.64	0.82	0.50	0.85	0.86	0.65	0.63	
X_{18}	0.43	0.70	0.59	0.63	0.73	0.50	0.61	0.34	0.43	0.62	0.71	0.22	0.66	0.66	0.70	0.50	0.68

3.3. Management Strategies Analysis

3.3.1. Driving Force Analysis

The interactive interaction of multiple factors acting together was much higher than the direct influence of a single factor acting alone, so synergistic effects must be considered in the policy design. We quantitatively measured the interaction effect of each factor by calculating the average of the interaction influence of each factor with the other 17 factors according to Equation (7); calculated the weights of each factor according to Equation (8) as well as the driving forces of each provincial administration according to Equation (9) (Tables 6 and 7).

Table 6. Weights for driving force analysis.

Code	Abbreviation	Average Value of Interaction Effects			Weight		
		Y_1	Y_2	Y_3	Y_1	Y_2	Y_3
X_1	NSC	0.72	0.46	0.63	0.0549	0.0563	0.0513
X_2	NHEI	0.74	0.34	0.70	0.0567	0.0420	0.0567
X_3	NEP	0.74	0.62	0.72	0.0563	0.0757	0.0582
X_4	NTSPT	0.70	0.66	0.75	0.0537	0.0802	0.0603
X_5	EF	0.75	0.38	0.72	0.0571	0.0465	0.0587
X_6	CGAE	0.61	0.47	0.65	0.0466	0.0571	0.0529
X_7	LGAE	0.60	0.49	0.65	0.0460	0.0595	0.0528
X_8	SDEI	0.77	0.38	0.57	0.0585	0.0465	0.0458
X_9	EIT	0.75	0.34	0.61	0.0573	0.0417	0.0496
X_{10}	IIT	0.82	0.66	0.74	0.0625	0.0808	0.0600
X_{11}	FDI	0.80	0.54	0.86	0.0611	0.0657	0.0692
X_{12}	OFDI	0.70	0.35	0.52	0.0534	0.0422	0.0418
X_{13}	ITR	0.82	0.38	0.81	0.0625	0.0470	0.0658
X_{14}	NISC	0.72	0.38	0.77	0.0552	0.0469	0.0627
X_{15}	GDP	0.77	0.52	0.70	0.0585	0.0639	0.0563
X_{16}	AVSI	0.72	0.35	0.67	0.0547	0.0422	0.0543
X_{17}	AVTI	0.70	0.51	0.71	0.0532	0.0616	0.0573
X_{18}	PCGDP	0.68	0.36	0.57	0.0518	0.0442	0.0463

Table 7. Driving force analysis.

NO.	Regions	All Students	Master's Students	Doctoral Students
1	Beijing	0.52	0.50	0.52
2	Tianjin	0.71	0.74	0.73
3	Hebei	0.59	0.60	0.60
4	Shanxi	0.74	0.76	0.75
5	InnerMongolia	0.76	0.79	0.77
6	Liaoning	0.64	0.66	0.65
7	Jilin	0.75	0.77	0.76
8	Heilongjiang	0.73	0.75	0.74
9	Shanghai	0.55	0.56	0.56
10	Jiangsu	0.16	0.16	0.16
11	Zhejiang	0.46	0.48	0.47
12	Anhui	0.63	0.66	0.64
13	Fujian	0.60	0.63	0.62
14	Jiangxi	0.67	0.69	0.68
15	Shandong	0.36	0.36	0.35
16	Henan	0.48	0.49	0.49
17	Hubei	0.57	0.58	0.57
18	Hunan	0.60	0.61	0.60

Table 7. *Cont.*

NO.	Regions	All Students	Master's Students	Doctoral Students
19	Guangdong	0.08	0.08	0.08
20	Guangxi	0.69	0.71	0.70
21	Hainan	0.84	0.87	0.85
22	Chongqing	0.70	0.73	0.72
23	Sichuan	0.53	0.54	0.54
24	Guizhou	0.74	0.76	0.75
25	Yunnan	0.70	0.73	0.71
26	Tibet	0.88	--	--
27	Shaanxi	0.65	0.67	0.66
28	Gansu	0.79	0.82	0.80
29	Qinghai	0.87	0.90	0.89
30	Ningxia	0.85	0.89	0.87
31	Xinjiang	0.78	0.81	0.79

3.3.2. Management Spatial Zoning

The medians of all students, master's students, and doctoral students were 0.67, 0.68, and 0.67, respectively, and we categorized the 31 provincial administrations in the study area into high and low-value types by classifying driving force using them as thresholds. Overlay analysis of ISC driving force grading results and BCG classification results by DDCAM made it possible to produce a spatial zoning scheme for the three groups, laying the foundation for differentiated management strategies and policy design.

For all students, internal governance zone, general retention zone, and general demonstration zone were key zonings with a large number of members, while the other zones had sparse members and external assistance zone has no members. It should be noted that the internal governance zone had most of its members clustered in northwest China, the general retention zone had all its members in the eastern seaboard, while all the members of the general demonstration zone were traditionally educationally developed regions, including Zhejiang and Jiangsu on the eastern seaboard, as well as Liaoning on the border, and Hubei, Sichuan, and Shaanxi in the interior (Table 8 and Figure 15).

For master's students, internal governance zone, general retention zone, and general demonstration zone were spatial zonings, and other zones had few members. In particular, there was only 1 member in the important demonstration zone and the external assistance zone, respectively. Notably, most members of the internal governance zone were clustered in the northwest, and all members of the general retention zone and the general demonstration zone were traditionally developed areas of education (Table 9 and Figure 16).

Table 8. Spatial zoning analysis of all students.

		Spatio-temporal Dynamics			
		Dog	**Gazelle**	**Cow**	**Star**
Driving Force	High	Internal Governance Zone	Important Development Zone	Important Retention Zone	Important Demonstration Zone
		InnerMongolia, Jilin, Qinghai, Ningxia, Tibet, Gansu, Xinjiang	Shanxi, Jiangxi, Hainan, Guizhou	Tianjin, Heilongjiang, Guangxi	Chongqing, Yunnan
	Low	External Assistance Zone	General Development Zone	General Retention Zone	General Demonstration Zone
			Hebei, Anhui, Henan, Hunan	Beijing, Shanghai, Fujian, Shandong, Guangdong	Liaoning, Jiangsu, Zhejiang, Hubei, Sichuan, Shaanxi

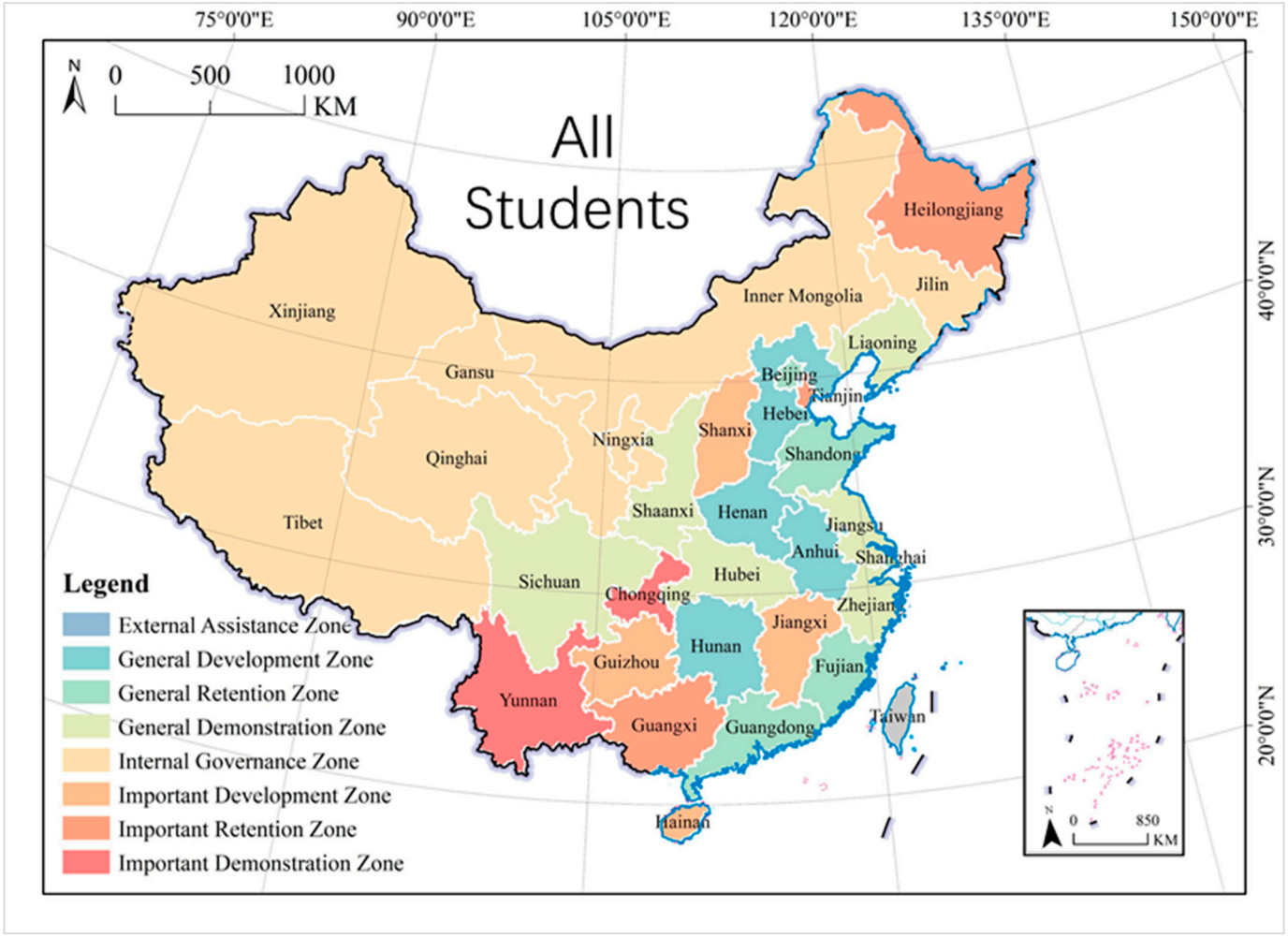


Figure 15. Spatial zoning analysis of all students.

Table 9. Spatial zoning analysis of master's students.

		Spatio-temporal Dynamics			
		Dog	**Gazelle**	**Cow**	**Star**
Driving Force	High	Internal Governance Zone	Important Development Zone	Important Retention Zone	Important Demonstration Zone
		InnerMongolia, Jiangxi, Guangxi, Chongqing, Gansu, Xinjiang	Shanxi, Hainan, Guizhou, Qinghai, Ningxia	Tianjin, Jilin, Heilongjiang	Yunnan
	Low	External Assistance Zone	General Development Zone	General Retention Zone	General Demonstration Zone
		Fujian	Hebei, Anhui, Henan	Beijing, Liaoning, Shanghai, Hubei, Guangdong	Jiangsu, Zhejiang, Shandong, Hunan, Sichuan, Shaanxi

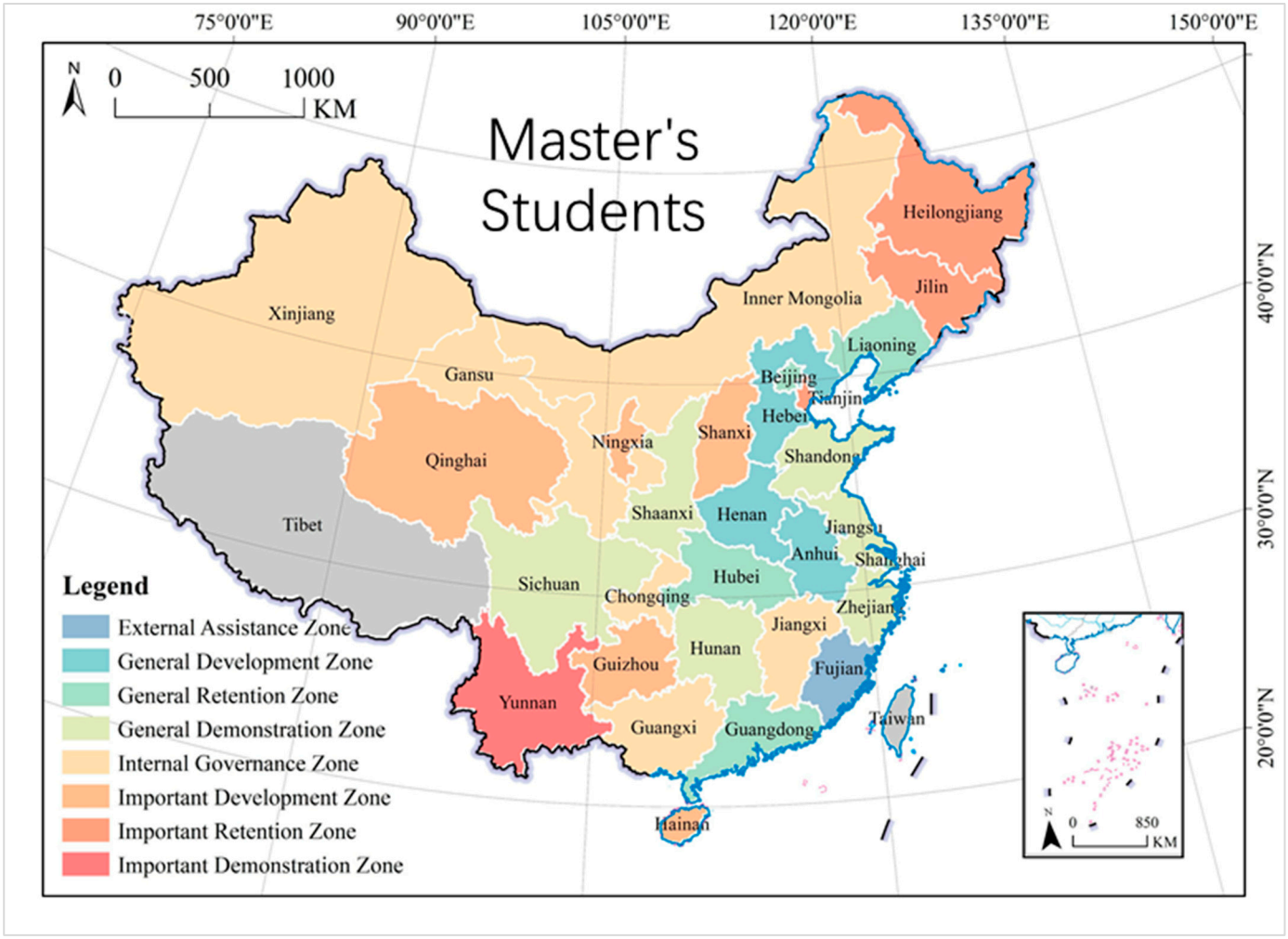


Figure 16. Spatial zoning analysis of master's students.

For doctoral students, the general retention zone and important development zone were key zonings, with the former being traditionally educationally developed areas and the latter clustered in the Yunnan-Guizhou Plateau and Loess Plateau regions. The internal governance zone and the general demonstration zone were important zones, with the former mostly clustered in the north and the latter scattered in distribution. The important retention zone and the important demonstration zone had only one member, respectively, and there was a gap in the external assistance zone (Table 10 and Figure 17).

Table 10. Spatial zoning analysis of doctoral students.

		Spatio-temporal Dynamics			
		Dog	**Gazelle**	**Cow**	**Star**
Driving Force	High	Internal Governance Zone	Important Development Zone	Important Retention Zone	Important Demonstration Zone
		Tianjin, InnerMongolia Jilin, Qinghai, Xinjiang	Shanxi, Jiangxi, Guangxi, Hainan, guizhou, Yunnan, Gansu, Ningxia	Heilongjiang	Chongqing
	Low	External Assistance Zone	General Development Zone	General Retention Zone	General Demonstration Zone
			Hebei, Henan	Beijing, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Hubei, Hunan, Guangdong	Anhui, Shandong, Sichuan, Shaanxi

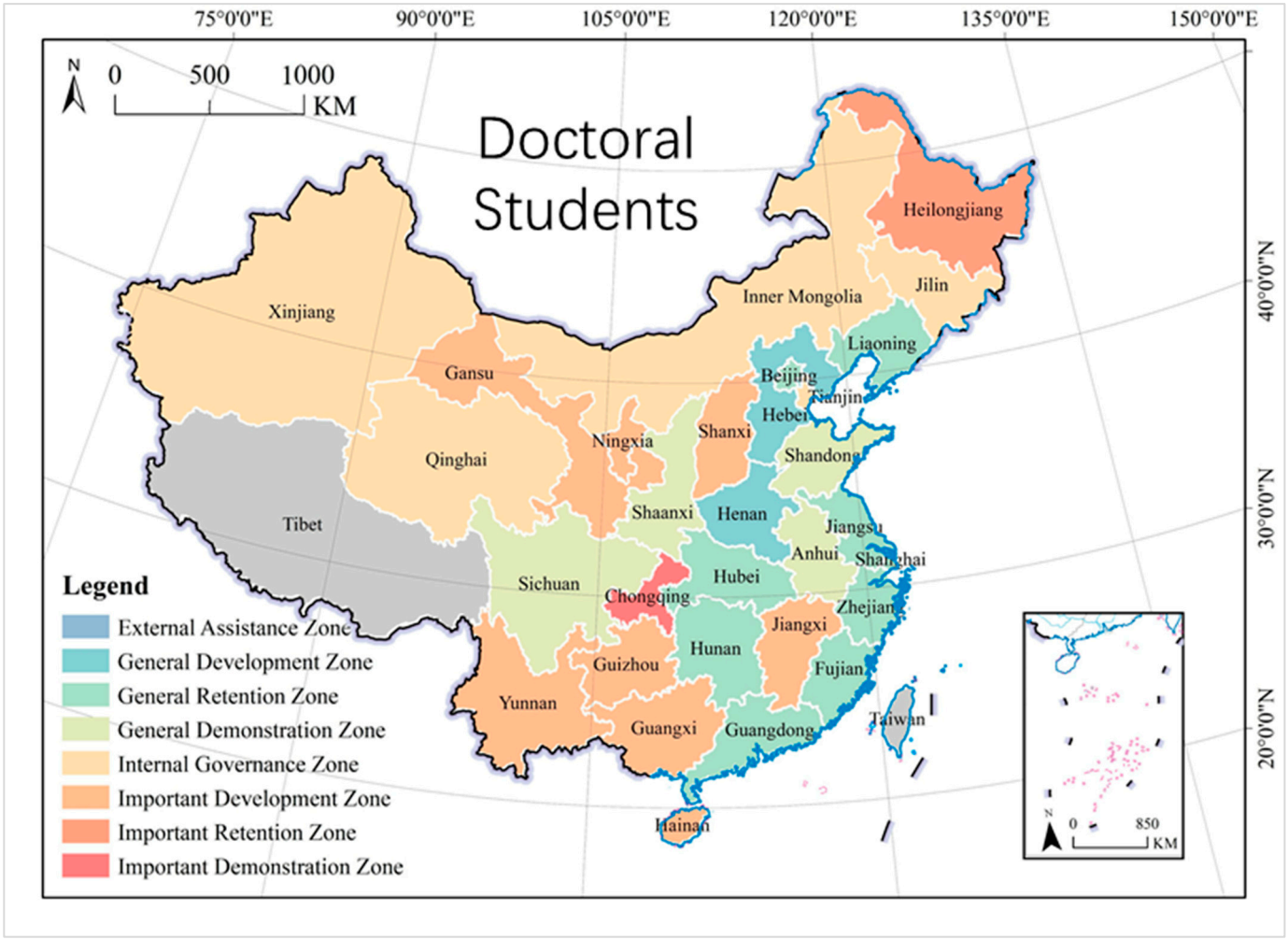


Figure 17. Spatial zoning analysis of doctoral students.

To summarize, ISC management should be tailored to local realities. Although the spatial zoning schemes were different for all students, master's students, and doctoral students, the internal governance zone, the important development zone, the general retention zone, and the general demonstration zone were all key spatial zonings for them. In addition, the few members of the important demonstration zone and the external assistance zone were marginal zonings for the three groups. Therefore, the central and local governments should work together and collaborate with multiple departments to formulate management strategies according to the characteristics and needs of the zonings, with focus on the key spatial zonings in the design of differentiated policies.

3.3.3. Differentiated Policy Design

For the internal governance zone, most of its members are ethnic minority autonomous regions and frontier zones, so they should take advantage of their geographic and ethnic minority strengths in developing their ISC management strategies and policy design. For example, Xinjiang Uyghur Autonomous Region, Inner Mongolia (Mongolian) Autonomous Prefecture, Qinghai, and Gansu, located in the northwestern border, received the vast majority of ISCs = coming from Central Asian countries such as Kazakhstan, Kyrgyzstan, Tajikistan, Afghanistan, and Mongolia due to their geographical proximity as well as ethnicity and bloodline connections. However, constrained by their own overall level of educational development and international cooperation mechanisms, they are facing great challenges in terms of both quantitative growth and qualitative improvement of ISCs. Therefore, they should, in the context of the "Belt and Road" initiative, take advantage

of their position as the core area of the Silk Road Economic Belt in the future, especially the opportunities of building the China–Pakistan, China–Central AsiaWest Asia, and China–Mongolia–Russia international economic corridors as well as the New Asia-Europe Continental Bridge, to strengthen their inter-provincial co-ordination and co-operation. They should also make full use of the comparative advantages of geography, affinity, descent, ethnicity, language, and history, with Lanzhou, Urumqi, Taiyuan, and Hohhot serving as the "engine" driving the internal high-quality education resources integration and optimization of the co-operation mechanism, to jointly build a demonstration area in China for overseas students from Central Asian countries.

For the important development zone, most of its members are border provinces or their neighboring provinces, with rapid ISC growth and strong driving forces. They have the potential to grow into emerging centers for studying in China in the future. For example, Guangxi, Yunnan, and Tibet, located on the southwestern border, and their neighboring Guizhou, Qinghai, and Hainan, which are adjacent to Vietnam, Myanmar, Laos, India, Bhutan, and Nepal, have a natural advantage and historical foundation for China's international cooperation in education with ASEAN and Southeast Asian countries. Guangxi has organized more than 20 "Study in Guangxi" international education exhibitions in Southeast Asian countries, and has established international education cooperation with more than 200 colleges and universities in these countries. Furthermore, many universities in Guangxi organize "ASEAN International Students Cultural Festival" in all its forms every year, inviting (prospective) international students and their parents to experience "Study in Guangxi" together. They should join hands with Guangdong, Fujian, Sichuan, and other neighboring regions in the future to take advantage of the construction opportunities of the 21st Century Maritime Silk Road, especially the China–Indo–China Peninsula and the Bangladesh–China–India–Myanmar International Economic Corridor. They should also make use of the advantages of geographic proximity, geographical connection, and humanistic affinities to further enhance their enrichment effect on ASEAN and Southeast Asian ISCs, and to jointly build a demonstration zone of study abroad education in China for ASEAN or Southeast Asian countries.

For the general retention zone, most of its members are the traditionally developed education zones in China, geographically dispersed in distribution. These regions have a high level of internationalization of higher education and can drive the education internationalization in the surrounding areas. It should be noted that they are relatively weak in terms of growth and drivers due to complex and diverse reasons, and therefore need to be analyzed on a case-by-case basis to develop individualized solutions. For example, Beijing needs to shift the focus of its internationalization of higher education in the future from expanding the number of ISCs to structural optimization and upgrading, and further increase the proportion of high-level international students at master's and doctoral levels. In addition, it should also further enhance the standardization of ISC management, create a high-quality, attractive, and sustainable international education system and environment, and build a world-class study abroad education center, so as to consolidate its leading position in China and raise the global brand reputation of "Study in Beijing". As for Shandong, it should, together with Liaoning, Jilin, Heilongjiang, and other regions, further enhance the attractiveness of overseas students from Japan, South Korea, and other countries, work together to build education demonstration areas for international students from East Asian countries, transform the original advantages into the emerging momentum, cultivate new advantages, inspire new vitality, and enhance the regional and international influence of the globalization of higher education.

For the general demonstration zone, all the members are the traditional developed areas of education in China, including Zhejiang and Jiangsu in the east, Shaanxi, and Sichuan in the west, and they should be committed to building demonstration areas for the internationalization of Chinese higher education with high quality in the future. The Chinese government is currently giving great impetus to the construction of "first-class universities and disciplines of the world", and the provinces involved should take

advantage of the policies to accelerate the internationalization and global development of their flagship universities [79,80], with targeted guidance highlighted in the policy design. For colleges and universities with more than 1000 international students, they should seek to play a supportive and exemplary role in upgrading the structure of the enrollments, education background and curriculum development. For colleges and universities with 200–1000 international students, they should strengthen university-enterprise cooperation with multinational corporations or those ready to "go global" in China, and create a special vocational education system for international students oriented to Chinese enterprises going abroad. For colleges and universities with less than 200 international students, they should focus on non-degree education in the future and work on the rapid expansion of international students, with international students seeking for language learning and short-term exchanges as a key growth point.

Other zones with few members at different degrees of internationalization of higher education should introduce innovative and flexible forms of development in the future to reverse their unfavorable development or consolidate their edges for development. Both the important retention zone with the internationalization of higher education at a high level in areas such as Tianjin, Liaoning, and Heilongjiang, and the general development zone with the internationalization of higher education at a low level in areas such as Hebei and Henan should strengthen their cooperation. They should establish a "one-to-one" support and cooperation mechanism early so that the latter may achieve leapfrog development relying on the advantages of the former. They both should jointly establish an international students' education service platform and build a cultural experience and internship base for international students, while improving their ISC service and management during cooperation. For the important demonstration zone, its members should strengthen innovative development in the future, and continuously explore and create new models for international student training. For example, the government may choose some universities and enterprises with international operations as a pilot project, co-organize order-deal international student training, and formulate training plans and course programs in accordance with the needs of the businesses. For the external assistance zone, due to its own low level of internationalization of higher education and weak capacity, to reverse the unfavorable situation of long-term marginalization by relying solely on colleges and universities, is impossible. The central government should increase the policy supply and support for the internationalization of their higher education in the future, and the local governments should also design a larger number of more flexible strategies in their management policies to encourage and guide the social capital to participate more in the management of ISCs. For example, the government should encourage qualified social organizations and businesses to expand the reach of ISCs by offering non-academic educational programs for international students, as well as internships and practical training positions related to the programs that international students are taking.

4. Discussion

The geographic distribution of ISCs in different provincial-level administrative regions of China has significant spatial effects, with complex and multifaceted spatio-temporal dynamics. First of all, all students, master's students, and doctoral students have significant diversity in their temporal trends and spatial distribution patterns, resulting in large differences in spatio-temporal dynamics. Classification of their spatial distribution into star, gazelle, cow, and dog types indicates that the ISC management should be tailored to the local conditions and the idea of "one size fits all" is not advisable [81]. That is, the central government should implement the zoning management strategy and supply different policies for all zones. For the local governments, they should formulate personalized strategic plans, action plans, and development policies for international students early on the basis of in-depth analysis of their own opportunities, challenges, strengths, and weaknesses in the internationalization of higher education. Secondly, the geographical distribution of ISCs in China's provincial administrations is characterized by significant spatial heterogeneity

and autocorrelation, which is of guiding significance and value in reminding decision makers not to overlook the influence of spatial effects when developing spatial zoning schemes [82,83]. In other words, the central and local governments should attach great importance to the spatial spillover effects of the highlands of internationalization of higher education and the spatial collapse effects of the depressions. The governments should also build support and partnerships to promote healthy competition and high levels of collaboration between different regions, with the differences and correlations between different provinces taken into account.

The driving mechanism of ISC spatio-temporal dynamics is very complex, with many influencing factors and significant interactions. First, different factors vary widely in direct influence and they are classified as key, important, and auxiliary factors. Notably, globalization and opening-up are more influential than educational condition and ability, especially import international trade, foreign direct investment, international tourism revenue have a very strong influence [84,85]. To some extent, this is an inspiration for policymakers, especially local governments that are lagging behind in the internationalization of higher education, and their own attractiveness to ISCs may lie beyond education. That is, improving the conditions and ability of education alone may not contribute to the improvement of the internationalization of their own higher education. It is necessary to take the advantage of the "Belt and Road" construction in the future and further place focus on the introduction of FDI [86], export trade [87] and international tourism [88,89] development. It promotes the high-quality development of its own economy and industry, while enhancing its attractiveness to ISCs [90]. Second, there is a significant synergistic effect between different factors, and the factor pairs exhibit the interaction of bifactor enhancement and nonlinear enhancement, with a large number of super factor pairs emerging. It suggests that the ISC management should not be limited to a single strategy, and it is required to design more diversified policy measures and rationally match them based on interactions and synergies for a better governance result. Finally, the international student driving mechanism at different levels in the management strategy and policy design should be matched with the development goals/orientations of higher education in different regions. On the one hand, the strength and mechanism of the influence of different factors on all students, master's students, and doctoral students are not exactly the same. For example, the direct driving force of NSC, SDEI, EIT is strong on EMAISC, but weak on EMDISC, and the influence on EMMISC is almost negligible (not statistically significant). Moreover, the goals and orientations of the internationalization of higher education in different regions also vary greatly, from comprehensive development for all international students to astute or special development for high-level international students. Therefore, it is necessary to combine the two in the design of international student management strategies and policies, so as to improve the accuracy and applicability.

It is worth noting that culture, ethnicity, and politics also significantly influence the distribution of ISCs. Although we did not include them in quantitative models due to the absence of suitable characterizing variables, many traces in both international and Chinese studies prove that they do have an impact on the globalization of education [91]. From an ethnic perspective, China is a multi-ethnic country. There are about 30 "transnational ethnic groups" (living in different countries across national boundaries) among the 55 ethnic minorities, including the Zhuang, Dai, Miao, Yi, Uyghur, Zang, Korean, Mongol, and Kazak, which are mainly located in the land border areas of China and have had a significant impact on the internationalization of China's education and economy. Transnational ethnic groups are characterized most by a strong sense of national identity, and they share the same or similar living customs and language, which provides them a natural advantage in studying in China. For example, international students from Vietnam, Southeast Asia, Central Asia, who share the same living customs with the Zhuang in Guangxi, the Dai and Yi in Yunnan, the Uyghurs in Xinjiang, and the Koreans in the Northeast, respectively, tend to cluster in the corresponding ethnic minority areas, and at the same time, the local governments have special preferential policies, funding programs, and projects for them.

From a cultural perspective, in addition to the national cultures stated above, China's historical and regional cultures are also highly attractive to international students, thus contributing to the fact that famous historical and cultural cities such as Beijing, Nanjing, and Xi'an have attracted a large number of international students [92,93].

DDCAM is a set of tools with high practical value for ISC management strategy and policy design, providing a decision-making basis for the management of international students in China and similar countries around the world. Firstly, out of the eight zones, the internal governance zone, the important development zone, the general retention zone, and the general demonstration zone have a large group of members, which the key to the design of differentiated policies. Secondly, for all students, master's students, and doctoral students, the membership of the eight zones has similarities and differences, suggesting that DDCAM has a high degree of sensitivity. For example, Inner Mongolia and Xinjiang have been in the internal governance zone, while Hunan is in the general development zone, the general demonstration zone, and the general retention zone. Thirdly, designing differentiated policies/solutions that address the challenges/problems in response to the common characteristics as well as the characteristic needs, strengths, and opportunities of all the members within the zone is a management strategy that is compatible with the stage of the internationalization of China's higher education and its target needs. It aims to promote multi-level interaction between national, local, and university globalization processes [94,95] and to integrate the resources of the government, the society, and the enterprises [96,97].

For policy designers in countries hosting international students, the distribution patterns of international students' destinations and origins are equally important [98], and clarifying their spatial imbalance characteristics and their driving mechanisms is a prerequisite for policy design [99]. The biggest theoretical contribution of this paper is the construction of a technical route that integrates the "dynamic analysis-driving mechanism-policy design" of international students for host countries or regions. It provides a basis for "evidence-based decision-making" in the management of ISCs, and it can be used as a reference for the management strategies and spatial policy design of international students in other countries. The research methodology, framework, results, and conclusions of this paper are applicable not only to countries in the northern hemisphere, but equally to those in the southern hemisphere. Developed countries such as Australia, New Zealand, and Argentina are the largest sinks for international students in the southern hemisphere, and Brazil, as a source, has also begun to improve its attractiveness to international students in recent years [100,101]. Countries such as Australia and New Zealand may assess the spatio-temporal dynamics of international students and design regulatory policies that reshape and optimize the spatial allocation of international educational resources, following the approach presented in this paper Brazil bears a strong resemblance to the early days of China. In the country, internationalization is a priority for higher education institutions and its education sector is trying to promote the transformation of country from a source to a destination for international students [102]. Brazil can learn from China's experience and methods in this process to encourage establishment of a specialized international education system early in different provinces and cities [103].

Based on the quantitative measurement of the spatio-temporal dynamics of ISCs, this paper reveals the driving mechanism of ISCs using a spatial econometric model. By introducing more analytical factors, it integrates the ideas of traditional theories such as the push-pull model [104,105], the international trade of the educational service [106,107], migration theory, and the gravity model [108], which is another theoretical contribution. In traditional research, most scholars focus on students rather than regions. This paper changes the perspective of the study by suggesting that international education administrators shift their vision from students to regions in order to improve the quality of management and services for international students. International education administrators and local governments should address two important questions: "Which regions are more attractive to international students?" and "How to improve the competitiveness of

international education through regional development environment modification?" The spatial measurement model developed in this paper, based on the analysis of geographic data on international students, can help the governments to conduct regional evaluation of the attractiveness for international students, so as to create more attractive environments for international students to grow up in, and to improve their status and competitiveness in the international education system.

Finally, this paper analyzes the development dynamics and driving mechanisms of master's and doctoral international students, constituting an innovative contribution in the field of high-level international student research. In most of the papers, international students are considered as a whole and not graded, leading to the neglect of the study of student structure, especially international students at high levels. With the increasing competition for international education in the new situation, the competition between countries for high-level international students, represented by master's and doctoral students, is becoming more intense. Governments and policy makers are more interested in understanding the high-level international students than in analyzing international students as a whole. By taking the master's and doctoral students as separate dimensions for analysis, this paper goes some way towards meeting the needs of the practice and finds that they are indeed unique.

However, there are some limitations to the present study due to the constraints of data acquisition and research methodology. For example, constrained by the underlying algorithm of GeoDetector, the action nature of different factors (positive or negative) cannot be identified by the driving mechanism analysis but relying on the experience of the researcher, although the strength and interaction relationship of different factors can be revealed properly. And the current complex international situation has a great impact on the mobility of international students, but constrained by data acquisition, there is no analysis of political factors in this paper [109]. These limitations are expected to be overcome in future studies. With the accumulation of data and information, and the increase in participating scholars, increasingly accurate analytical results available by making changes to the research methods, cases, and their data.

5. Conclusions

The management of international students in the context of the "Belt and Road Initiative" and the globalization of higher education has become a universal challenge that governments around the world have to face. There is an urgent need for academics to provide a foundation or tools to support "evidence-based decision-making" exercise in countries and regions hosting international students. Based on a combination of BCG, GeoDetector, DDCAM, and other spatial measurement models and analytical methods, this paper designed a technical route integrating "dynamic analysis—driving mechanism—policy design" for international students, and conducted an empirical study on China, trying to offer a basis for ISC management strategy and space policy design. The findings are as follows:

First, the spatio-temporal dynamics of ISCs showed significant differences and spatial effects. In the time dimension, growth and decline coexist, indicating increasingly differentiated trends in ISC development. In the spatial dimension, spatial heterogeneity and correlation coexisted, suggesting that ISC management should be tailored to local conditions and regional collaboration. In the spatio-temporal dimensions, the emergence of star, gazelle, cow, and dog types suggests that the "one size fits all" homogeneity and unification policy for ISC management is not appropriate any longer. In the dimension of international students, the spatio-temporal dynamics and spatial effects of all students, master's students, and doctoral students have both commonalities and differences, suggesting that policymakers should conduct an in-depth study of different levels and types of ISCs according to the development goals/strategic orientations.

Second, there are a large number of factors affecting the spatio-temporal dynamics of ISCs with significant interaction effects and complex driving mechanisms. The driving

force of different factors varied greatly, and they were categorized into key, important, and auxiliary types by intensity of influence. In terms of interaction mechanisms, there were considerable synergistic effects, and the interactions were dominated by bifactor enhancement, with a large number of super-interacting factor pairs emerging. In addition, the intensity and power mechanism of the same factor's influence on ISCs of different structures and levels are different, and deconstructive analysis can only enhance the precision of the results and the application value of the conclusions.

Third, China should consider zoning-based ISC management, and make a design to implement differentiated policies. The internal governance zone, the important development zone, the general retention zone, and the general demonstration zone are key zonings, serving as the focus of management strategies and policy design. The DDCAM is able to reveal the similarities and differences among all students, master's students, and doctoral students due to its high utility and sensitivity, thus enhancing the precision of the analyzed results.

Internationalization is the development trend of higher education, and the government has the right to allocate related resources. Most of the current research focuses on student analysis and geographic analysis of international students, resulting in a weak correlation with government policy design. With the increasing competition for international education, especially after the COVID-19 crisis, countries around the world are accelerating the optimization of their international education systems, and local governments are working to transform their own environments to make them more attractive to international students. Therefore, both in terms of theoretical innovativeness and practical needs, the study of the geographical distribution of international students and regional management policies are an emerging hot spot. New researchers may continue to deepen their research in the following directions: first, a multi-scale comparative study at the national, regional, provincial, and municipal levels to reveal the spatial scale effects of international education; second, comparative studies of different countries, especially comparative analyses of developed–developing countries, north–south hemisphere countries, and east–west countries between the United States, Australia, China, Europe and other countries; and third, further updating the data on international students and incorporating more uncertainties such as cultural background, development history, government support, and student attitudes into the study.

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