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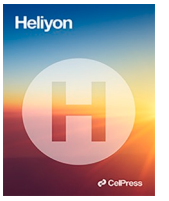

Research article

Scale or effectiveness? The nonlinear impact of talent agglomeration on high-quality economic development in China

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ABSTRACT

Talent agglomeration serves as a vital pathway for achieving high-quality economic development. This paper, based on provincial panel data from China spanning 2011–2020, first analyses the impact of talent agglomeration on high-quality economic development from two dimensions: the talent agglomeration scale and effectiveness. Second, with innovation activity as a threshold variable, this paper explores the nonlinear impact of the talent agglomeration scale and effectiveness on economic efficiency improvement and economic structure optimization. This study finds that (1) the main driving force for high-quality economic development within the sample period comes from the talent agglomeration scale, while the promoting role of talent agglomeration effectiveness has not yet passed significant tests. (2) Under different levels of innovation activity, the talent agglomeration scale has a diminishing marginal utility impact on economic efficiency improvement and economic structure optimization; talent agglomeration effectiveness also has different nonlinear effects on economic efficiency improvement and economic structure optimization.

1. Introduction

Talent, the quintessential harbinger and creator of groundbreaking knowledge, assumes a pivotal role in shaping the trajectory of economic development [1]. In the relentless battleground of the war for talent, the phenomenon of talent agglomeration favoring economically advanced regions has emerged as a ubiquitous occurrence [2,3]. However, the high-quality development of the economy necessitates not only the accumulation of talent resources but also the adept utilization and discovery of the value embedded within these resources. Against the backdrop of China's continuously declining birth rate, achieving the transition from the scale dividend to the effectiveness dividend has become the crucial entry point from which to drive comprehensive economic development. Therefore, we need to clarify the relationship between talent agglomeration and high-quality economic development and explore how to use talent agglomeration to promote economic efficiency improvement and economic structure optimization. This study has important theoretical and practical significance for the achievement of balanced and high-quality economic development in each region.

Talent agglomeration is the process of talent flowing from different regions to a specific area under the influence of certain factors in a certain period [4,5]. As the most dynamic factor in regional innovation and economic development, talent has triggered in-depth research by scholars, and a series of excellent results have been obtained. A subset of scholars contend that talent agglomeration positively influences economic development [6,7]. On the one hand, talent agglomeration directly promotes economic development.

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Bergin [8]] found, with the help of a new macroeconomic model, that the economic output of areas with a high level of talent agglomeration is much greater than that of areas with a low level of talent agglomeration. Yang and Du [6] believed that under the influence of material and spiritual incentives, as well as the rule of law system, talent agglomeration can realize value through the agglomeration effect. Huang et al. [7] also discussed the important role of talent agglomeration in national economic development. On the other hand, Schumpeterian economic theory establishes a reliable link between the "regrouping of factors of production" of innovation and economic development [9] (p.60). Therefore, as an enabler of the combination of production factors, the agglomeration and flow of talent may play a role in high-quality economic development by affecting innovation. That is, the increase in human capital needed to promote economic development is due mainly to the improvement of innovation ability [2]. For example, Romer [10] and Lucas [11] found that the agglomeration of investment talent and the accumulation of knowledge positively affect the formation of production factors, such as physical capital. Moreover, the investment effect of talent agglomeration exhibits the characteristics of an increasing marginal scale, which promotes sustained and stable economic growth. Informed by agglomeration economics, Yang and Pan's study, utilizing a Chinese dataset, demonstrated that talent agglomeration exerts a sustained positive effect on economic growth, notably through the stimulation of housing market dynamics [12].

In contrast, several scholars have found that excessive talent agglomeration may lead to problems such as idle and wasted talent and rising management costs, which have negative impacts on economic development [13]. Xu and Wu [14] found, through an empirical study, that the regional innovation effect generated by talent agglomeration bears the risk of reverse spillover, which may restrict regional economic growth. Liu and Liu [15] also concluded that an excessive concentration of innovation factors results in inefficient allocation, leading to product congestion and lower performance levels. In addition, Liu [16] noted that the agglomeration of different types of talent plays different or even opposite roles in regional economic development, with the agglomeration of professional knowledge talent positively promoting regional economic development. In contrast, the agglomeration of specialized skill talent has a negative inhibitory effect.

Although the current research has made some progress, the following aspects need to be further explored. (1) The academic community has not reached a unified conclusion on the relationship between talent agglomeration and economic development. The existing research has focused primarily on the impact of talent agglomeration on the improvement of economic efficiency but has paid less attention to its effect on economic structure optimization. What role does talent agglomeration play in high-quality economic development? However, whether its impact on economic efficiency improvement and economic structure optimization is constant needs to be further explored. (2) Existing studies have neglected the differential impact of talent aggregation on high-quality economic development at different levels of innovation activity. A more comprehensive and detailed exploration of the multifaceted relationships among innovation activity, talent aggregation and high-quality economic development is lacking.

Therefore, this paper first sets out to explore the impact of talent agglomeration on high-quality economic development through two dimensions: the talent agglomeration scale and the talent agglomeration effectiveness. At the same time, this paper divides high-quality economic development into two sub-dimensions: economic efficiency improvement and economic structure optimization. Second, this paper explores the nonlinear impact of different dimensions of talent agglomeration on high-quality economic development using innovation activity as a threshold variable. Based on these findings, targeted policy recommendations are proposed.

The marginal contributions of this paper are as follows. First, by delving into the various dimensions of talent agglomeration and its impact on high-quality economic development, this paper offers new perspectives and depth to research in the field. Second, by examining the nonlinear effects of talent agglomeration at different levels of innovative activity, this paper provides theoretical guidance for local governments to optimize talent structures and foster economic growth. Finally, this work analyses the distribution characteristics of innovation activity from the perspective of regional variability, extending the existing research on innovation activity.

The rest of the paper is structured as follows. In Section 2, we present the research hypotheses. Section 3 describes the model construction and variable measurement. Section 4 presents the results of the data analysis, including benchmark and threshold regression analyses. Section 5 presents the research conclusions and implications of this paper.

2. Research hypothesis

Talent, as an indispensable propellant and a scarce reservoir, represents the linchpin for fostering the innovative development of regional economies [2]. The phenomenon of talent agglomeration, serving as a distinctive manifestation of talent mobility and resource allocation, assumes a paramount role in this intricate ecosystem. On the one hand, an increase in the talent agglomeration scale not only triggers the accumulation of knowledge and the diffusion of technology but also catalyzes the social collaboration of innovation activities [17]. This form of social collaboration further enhances knowledge cocreation and sharing within the region, injecting vitality and momentum into high-quality economic development [18]. On the other hand, regions that attract talent frequently emerge as hubs for specialized industries, creating an industrial clustering effect [19]. In these areas, the synergistic cycle of talent aggregation and industrial growth not only fosters innovation but also cultivates regional competitive advantages. The accrual of such advantages enhances the region's economic quality, thereby increasing its attractiveness and competitiveness.

In contrast, the study conducted by Čadil [20] suggested a nuanced perspective: the presence of talent does not necessarily ensure the continued stability of economic development, nor does it invariably enhance the resilience of such development. Shen and Li [21] further posited that the underutilization of aggregated talent may inadvertently escalate regional production, circulation, and human management costs. This scenario could, to a certain degree, pose an impediment to robust economic development. It has been established that the greater the effectiveness of talent under agglomeration is, the more significant the positive effect on the level of economic development [22]. Nevertheless, the essence of talent effectiveness is rooted in enhancing talent allocation efficiency.

Compared to the increase in the scale of talent agglomeration, the realization of talent agglomeration effectiveness faces many uncertainties. First, uneven regional development has led to differences in the degrees of effectiveness of talent gathering in different regions. Some areas with relatively lagging degrees of development may lack the hardware and software conditions to attract talent, which limits the full effectiveness of talent gathering. Second, inconsistent policy implementation is also a key factor. Even if there is a good talent attraction policy, if there are varying degrees of deviation or instability in the implementation process, then the actual gathering and development of talent will be hindered [23]. In addition, high living costs and pressure may deter some talent, affecting their willingness to settle and develop in specific areas. In a study using Chinese data as a sample, Wang [24] found that although the scale of talent agglomeration is relatively high, the actual utilization rate is relatively low. Based on this, this paper proposes the following assumption:

Hypothesis 1. The promotion of high-quality economic development is derived primarily from the talent aggregation scale. The positive effect of talent aggregation effectiveness on high-quality economic development has not been fully examined.

Innovation activity, as delineated by Hu and Xue [25], serves as a metric for the efficacy of innovative outputs produced by respective actors within a region, which is achieved through the amalgamation of diverse innovative resources, guided by pertinent policies, and mirrors the innovative vigor that is intrinsic to regional economic development. Robust innovation activity signifies a superior regional innovation environment and a well-structured innovation system. Such a milieu is advantageous for bolstering the effect of talent agglomeration, thereby fostering a virtuous cycle of innovation and talent agglomeration scale enhancement. First, motivated by their intrinsic pursuit of profit, individuals with high skill and expertise levels are naturally drawn to regions characterized by robust institutional frameworks and dynamic environments conducive to innovation [3]. Hence, regions exhibiting high innovation activity levels prove to be effective at attracting talent, thereby fostering an increase in the talent agglomeration scale. Second, under conditions of information asymmetry and uncertain expectations, certain talent may resort to emulating the direction of other talent flows or public opinion, a phenomenon that triggers a 'herding effect', as elucidated by Davison [26]. This behavior can exacerbate talent concentration within a specific region, leading to an amplification of the agglomeration effect.

Nonetheless, when innovation activity reaches excessive levels, competition for talent within the region escalates, a condition that may dampen enthusiasm for talent output and engender a misalignment of talent resources [27]. This situation complicates the rational allocation of innovation resources and can potentially trigger significant talent outflow within the region. The innovation effect, originally fostered by the talent agglomeration scale, may experience counteractive spillover, thereby diminishing its role in bolstering high-quality economic development. Consequently, whether in terms of enhancing economic efficiency or optimizing the economic structure, the propelling influence of the talent agglomeration scale is likely to be attenuated. Therefore, this paper proposes the following hypothesis:

Hypothesis 2. As innovation activity improves, the role of the talent agglomeration scale in promoting high-quality economic development progressively weakens.

Under the influence of innovation activities, the impact of talent agglomeration effectiveness in various regions on high-quality economic development also shows nonlinear characteristics. First, appropriate innovation activity not only promotes the emergence of new technologies and methods but also accelerates the generation and dissemination of information resources, which helps improve the fluidity of information in the economy, making it easier for regional innovative entities to obtain the latest market trends and competitive dynamics and allowing them to more flexibly adjust their strategies. Second, appropriate innovation activity encourages the accumulation and sharing of knowledge resources. In the innovation process, effective talent aggregation can help accelerate the allocation of knowledge resources, reduce information asymmetry and resource waste, and provide substantial support for improving economic efficiency and optimizing the economic structure [28].

Both excessively low and excessively high levels of innovation activity can be detrimental to the role of talent agglomeration efficiency in promoting high-quality economic development. A lower degree of innovation activity can lead to a weakened regional rooting of talent agglomeration, which is characterized by a lack of effective communication and interaction among diverse talent within the locality, resulting in a propensity for talent agglomeration to engage with external institutions and businesses [29]. Consequently, the region becomes heavily dependent on external resources, failing to fully leverage the potential of talent agglomeration and thereby undermining local autonomous innovation capabilities, which are crucial for enhancing high-quality economic development. Conversely, when innovation activity is at a high level, the enhanced efficiency of talent agglomeration fosters strong regional attachment among talent, leading to a 'lock-in effect' [30]. This effect causes the region to not only attract resources that are

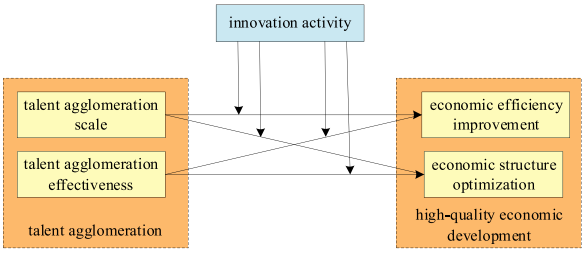

Fig. 1. Theoretical framework.

highly aligned with its current development trajectory but also repel high-quality, diverse resources, which can ultimately transform the area into a closed system, impeding economic progress. Based on the above aspects, Hypothesis 3 is proposed as follows:

Hypothesis 3. There exists an optimal range of innovation activity that maximizes talent agglomeration effectiveness for high-quality economic development.

The theoretical framework of this paper is shown in Fig. 1.

3. Model construction and data

3.1. Empirical model

(1) Benchmark estimation model

This paper quantitatively analyses the impact of talent agglomeration on high-quality economic development by constructing a benchmark regression model with ordinary least squares (OLS) regression. The analytical framework starts from two dimensions, namely, scale and effectiveness, to explore its potential mechanism of action in terms of the quality of economic development. The specific model setting is shown in Equation (1).

$$HED_{it} = \beta_0 + \beta_1 TA_{it} + \beta_2 control_{it} + u_i + \varepsilon_{it} \tag{1}$$

In Equation (1), i represents different regions; t represents different years; High-quality economic development(HED) is the dependent variable in this paper, including economic efficiency improvement (EEI) and economic structure optimization (ESO); talent agglomeration (TA) represents the core explanatory variable, which includes the talent agglomeration scale (TAS) and talent agglomeration effectiveness (TAE); control represents a series of control variables that have an impact on high-quality economic development, including economic development level, infrastructure construction, foreign investment and degree of marketization; u_i represents regional fixed effects; and ε_{it} represents a random interference term.

(2) Threshold regression model

The aim of this paper is to examine the association between talent aggregation and high-quality economic development, with a particular emphasis on the role of innovation activity. To gain a comprehensive understanding of this intricate relationship, this paper employs a threshold regression model with innovation activity as the threshold variable, aiming to elucidate its moderating effect on the link between talent agglomeration and high-quality economic development. The rationale for selecting the threshold regression model is its ability to reveal whether there exists a significant disparity in the influence of talent aggregation on the quality of economic development across different levels of innovation activity and how this influence varies with different levels of innovation activity. Furthermore, the model can identify the threshold of innovation activity, which signifies the tipping point of the impact of talent agglomeration on the quality of economic development, thereby providing a more precise foundation for policy formulation.

First, using innovation activity as the threshold variable, a threshold regression model is constructed to analyze the impact of the talent agglomeration scale on high-quality economic development. This model is based on Equation (2) as follows:

$$HED_{it} = \beta_0 + \beta_1 TAS_{it}(INNOV \le \gamma_1) + \beta_2 TAS_{it}(INNOV > \gamma_1) + \beta_3 control_{it} + \varepsilon_{it} \tag{2}$$

where INNOV, innovation activity, is the threshold variable; γ represents the threshold value to be estimated; and I(●) is the indicator function, which takes the value of 1 when the conditions in the parentheses are satisfied and 0 otherwise. The meanings of the other variables are the same as those in Equation (1). Equation (2) shows a single-threshold regression model, which can be extended to a double-threshold model or a multithreshold measurement model as needed. The double-threshold model is shown in Equation (3).

$$\begin{aligned} HED_{it} = {} & \beta_0 + \beta_1 TAS_{it}(INNOV \le \gamma_1) + \beta_2 TAS_{it}(\gamma_1 < INNOV \le \gamma_2) \\ & + \beta_3 TAS_{it}(INNOV > \gamma_2) + \beta_4 control_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

where γ_1 and γ_2 are double-threshold values. The other variables have the same meanings as in Equation (2).

In the same way, the single and double-threshold regression models for the impact of talent agglomeration effectiveness on high-quality economic development with innovation activity as the threshold variable are set as Equation (4) and Equation (5).

$$HED_{it} = \beta_0 + \beta_1 TAE_{it}(INNOV \le \gamma_1) + \beta_2 TAE_{it}(INNOV > \gamma_1) + \beta_3 control_{it} + \varepsilon_{it} \tag{4}$$

$$\begin{aligned} HED_{it} = {} & \beta_0 + \beta_1 TAE_{it}(INNOV \le \gamma_1) + \beta_2 TAE_{it}(\gamma_1 < INNOV \le \gamma_2) \\ & + \beta_3 TAE_{it}(INNOV > \gamma_2) + \beta_4 control_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

3.2. Variable description

(1) Dependent variable. First, economic efficiency improvement (EEI) manifests as the enhancement of productivity and economic growth resulting from the input of production factors. EEI serves as a crucial measure of the quality of economic growth and the

degree of technical advancement and management efficiency in a given country or region [31]. Drawing from the study by Liu et al. [32], this paper employs total factor productivity as the gauge for economic efficiency improvement.

Among the various methods for measuring total factor productivity, the DEA-Malmquist index is frequently used, and this paper also utilizes this method for estimation. For the selection of total factor productivity measurement indicators, this paper uses the GDP of 30 provincial regions as output indicators. The number of employees in each region is taken as a labor input indicator. The stock of fixed capital is used as a capital input indicator. Given that there are no direct statistical indicators for capital stock in China, this paper applies the perpetual inventory method to measure fixed capital stock based on the estimation method proposed by Shan [33]. The calculation is shown in Equation (6).

$$K_{it} = K_{i(t-1)} * (1 - \delta_{it}) + I_{it} \,/\, P_{it} \tag{6}$$

where i represents the provincial region, t denotes the year, K symbolizes the capital stock, I represents total fixed asset investment, P indicates the fixed-asset investment price index, and δ represents the depreciation rate. Drawing on the research of Zhang et al. [34], the depreciation rate is set at 9.6 %. Using 2010 fixed asset investment data as the baseline for capital stock estimation in this paper, China's capital stock from 2011 to 2020 is computed using the aforementioned formula. Owing to the presence of data scarcity in some areas, the interpolation method is employed to address this issue. With data from 30 decision units, one output variable, and two input variables, the Malmquist index for each region from 2011 to 2020 can be derived using DEAP2.1.

Second, economic structure optimization (ESO) primarily captures the harmonization and rationalization of supply and demand structures across industries; it also mirrors the compatibility of the input structure of production factors with the output structure. Following the study by Gan et al. [35], this paper employs the Theil index to gauge the rationality of the economic structure. The Theil index is calculated using Equation (7).

$$T_{\mathrm{i}} = \sum_{s=1}^{3} \lambda_{\mathrm{is}}^{Y} \ln \frac{\lambda_{is}^{Y}}{\lambda_{is}^{s}} \tag{7}$$

In the formula, i is the provincial region, where i = 1,2,3, …,30. λ_{is}^{Y} is the proportion of the output value of industry s in province i to the total output value of the three industries in region i. λ_{is}^{s} is the proportion of employment in industry s in province i to the total employment in the three industries in province i. When the Theil index is negative, a larger index value indicates greater deviation from the equilibrium state, signifying an increasingly unreasonable economic structure. In this paper, the reciprocal of the Theil index is taken to make this positive. That is, the larger the reciprocal of the Theil index is, the more rational the economic structure. Conversely, a smaller reciprocal implies a more unreasonable economic structure. This approach serves to measure the degree of rationalization in the economic structure of each region.

(2) Independent variable. The independent variable in this paper is talent agglomeration (TA), which includes the talent agglomeration scale (TAS) and talent agglomeration effectiveness (TAE). Drawing from the methodology of Wang and Wang [36], this paper measures the talent agglomeration scale using talent locational entropy. This method involves first calculating X, which represents the number of employees with a bachelor's degree or higher in each region relative to the total number of employees in that region. Subsequently, we calculate Y, which denotes the number of employed persons with a bachelor's degree or higher at the national level relative to the total number of employed persons. The talent agglomeration scale is then measured by the quotient obtained by dividing X by Y.

Talent agglomeration effectiveness serves as a crucial measure of the extent and efficacy to which talent is utilized. Following the approach of Wang [37] (p. 12), the metric "scale of talents consumed by the production unit GDP" is chosen to assess the effectiveness of talent agglomeration. Grounded in existing research and the interpretability of the analytical results, this study measures talent agglomeration effectiveness by dividing the value of provincial GDP by the number of employees with a bachelor's degree or higher. A higher value indicates greater talent value and effectiveness within the region.

(3) Threshold variables. This study designates innovation activity (INNOV) as the threshold variable, aiming to uncover whether the impact of talent agglomeration on high-quality economic development varies dynamically under different levels of innovation activity and to elucidate the threshold characteristics. Innovation activity encapsulates the prevailing interest, support, and participation in innovation within a region, emphasizing the so-called innovation atmosphere of the area. Drawing from the research of Hu and Xue [25], this paper employs the natural logarithm of the number of patent applications as a measure of innovation activity.

(4) Control variables. In addition to the influence of talent agglomeration, high-quality economic development is affected by other factors. This paper identifies the level of economic development, foreign direct investment, infrastructure construction, and degree of marketization as control variables. For the level of economic development (PGDP), this paper uses GDP per capita to measure regional economic development and takes logarithmic treatment. Studies on foreign direct investment (FDI) have shown that opening up to the outside world can have a meaningful impact on the economic development of China's regions. This paper uses the proportion of foreign direct investment in GDP to measure this variable. In this paper, infrastructure construction (INFR), which reflects the current development of the transportation system in each region, is measured by the

length of the fiber optic cable lines. The degree of marketization (MARK) reflects the function and role of the market in resource allocation. Drawing on the Fan Gang marketization index for measurement, this study addresses instances of missing data by adjusting the data through regression equation fitting.

3.3. Data sources

This paper employs Chinese data to empirically examine the relationships among talent agglomeration, innovation activity, and high-quality economic development. The inclusion of Chinese data in this study is justified for several reasons. First, China has undergone remarkable economic growth over the past few decades and has emerged as the world's second-largest economy. Consequently, the utilization of Chinese data allows for the investigation of a representative and significant case. Second, China has a vast population and abundant talent resources. Moreover, the country has witnessed rapid urbanization and population mobility in recent years, leading to the concentration of talent in major cities and innovation hubs. By examining the effect of talent agglomeration in these areas, we can uncover its impact on economic development and extract valuable lessons and experiences related to the economic advancement of other countries or regions. Third, the Chinese government has consistently emphasized talent development and the implementation of an innovation-driven development strategy. The analysis of Chinese data enables an exploration of the government's policy measures concerning talent concentration and an assessment of their influence on high-quality economic development. Consequently, this research can provide valuable references and insights for policy formulation in other countries or regions.

Due to the missing data for Tibet, Hong Kong, Macau and Taiwan, this paper uses panel data from 30 provincial regions in China from 2011 to 2020 for empirical analysis. The economic efficiency improvement, economic structure optimization, and innovation activity data used in this article come from the China Statistical Yearbook. The talent agglomeration data come from the China Labor Statistics Yearbook. The data on the level of economic development, foreign direct investment, and infrastructure construction come from various regional statistical yearbooks and EPS data platforms. The data on the degree of marketization come from the China Provincial Marketization Index Report. For some missing values, linear interpolation is used to supplement the data. The descriptive statistics of each indicator are shown in Table 1.

4. Empirical results

4.1. Baseline regression results

The results are validated using a fixed effects model based on the discriminant Hausman statistic. The measured results are shown in Table 2. First, Models (1) and (4) report the impact of the talent agglomeration scale on high-quality economic development. The results show that the talent agglomeration scale significantly promotes economic efficiency improvement and economic structure optimization, with estimated coefficients of 0.414 and 7.325, respectively, which both pass the significance test at the 1 % level. Models (2) and (5) report the impact of talent agglomeration effectiveness on high-quality economic development. The regression results show that talent agglomeration effectiveness significantly contributes to the improvement of economic efficiency ($\beta = 2.139$, $P < 0.01$). However, the positive effect of talent agglomeration effectiveness on economic structure optimization does not pass the significance test ($\beta = 1.398$). This finding also means that the effectiveness of talent agglomeration has not yet been fully developed. This finding is consistent with the findings of Xu and Wu [14] who believe that the innovation-driven advantage of talent agglomeration effectiveness is not sufficiently transformed into a driving force for economic development and that the phenomenon of reverse spillover of technological innovation may occur, thus resulting in the less-than-obvious promotion of economic development. The above analysis shows that Hypothesis 1 is supported.

Second, when considering Model (3), it is found that when the explained variable is economic efficiency improvement, talent agglomeration effectiveness has a greater contribution than does the talent agglomeration scale ($1.477 > 0.307$, $p < 0.01$). Similarly, when considering Model (6), it is found that when the explained variable is economic structure optimization, the promotion effect of the talent agglomeration scale ($\beta = 7.391$, $p < 0.01$) is greater than that of talent agglomeration effectiveness ($\beta = -3.089$, $p > 0.1$). Therefore, for regions with relatively low economic efficiency levels, emphasis should be placed on enhancing talent agglomeration effectiveness, which can be achieved by stimulating and leveraging the value of concentrated talent to improve the efficiency of production factor utilization, thereby accelerating economic development and enhancing its quality. For areas where the economic

Table 1
Descriptive statistics of the variables.

Variable Type	Variable	Mean	Standard Deviation	Minimum	Maximum
Dependent Variable	EEI	1.274	0.235	1	2.208
	ESO	13.939	10.181	4.398	51.207
Independent Variable	TAS	1.118	0.572	0.492	3.917
	TAE	0.126	0.096	0.020	0.574
Control Variable	INNOV	10.41	1.438	6.194	13.510
	PGDP	10.736	0.835	3.949	12.009
	INFR	13.270	1.465	1.591	15.118
	FDI	0.477	1.157	0.049	10.902
	MARK	5.709	1.761	0.503	9.18

Table 2
Benchmark estimation results.

Variable	EEI			ESO		
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
TAS	0.414*** (11.07)		0.307*** (8.27)	7.325*** (8.02)		7.391*** (8.03)
TAE		2.139*** (10.25)	1.477*** (7.31)		1.398 (0.26)	−3.089 (−0.63)
PGDP	0.075 (1.17)	0.217*** (3.36)	0.107** (1.82)	3.953** (3.13)	9.693*** (7.17)	4.309*** (3.11)
INFR	−0.089*** (-2.89)	−0.216*** (−8.058)	−0.095*** (-3.39)	−3.309*** (-5.29)	−5.024*** (-7.62)	−3.06*** (−5.19)
FDI	−0.666** (-21.25)	−0.732*** (−23.92)	−0.661*** (−23.13)	−0.669 (-0.64)	1.781 (1.48)	−0.447 (−0.40)
MARK	0.223*** (14.39)	0.391*** (−31.23)	0.289*** (17.26)	2.630*** (6.36)	2.766*** (4.66)	2.41*** (4.54)
Constant	10.394*** (27.46)	11.168*** (31.16)	0.307*** (8.27)	−7.476 (-0.49)	−40.268** (-2.33)	7.391*** (8.03)
R^2	0.916	0.912	0.931	0.7781	0.722	0.778
F	558.88***	530.74***	569.98***	179.53***	133.25***	149.32***

structure is awaiting optimization, it is even more essential to increase the talent agglomeration scale. The goal is to shift the dynamic from talent outflow to talent inflow, infusing new vitality into economic construction.

4.2. Threshold regression results

The benchmark regression model shows that talent agglomeration positively affects high-quality economic development. A threshold effect test is also needed when considering whether innovation activity causes a sudden change in the structure of this effect.

(1) Results of threshold regression analysis of the effect of the talent agglomeration scale on high-quality economic development

With innovation activity as the threshold variable, the results of the threshold test of the nonlinear impact of the talent agglomeration scale on high-quality economic development are shown in Table 3. When the explained variable is economic efficiency improvement, under the condition of repeated sampling 600 times by the bootstrap method, the single threshold of innovation activity passed the significance test at the 1 % level. This finding denotes the existence of a discernible threshold in innovation activity, which modulates the influence of talent agglomeration scale on the augmentation of economic efficiency. Similarly, it can be seen that there is also a single threshold for the talent agglomeration scale in promoting economic structure optimization.

The results of the threshold estimation show that the single-threshold values of the effect of the talent agglomeration scale on economic efficiency improvement and economic structure optimization are 9.059 and 11.571, respectively. The 95 % confidence intervals of the threshold estimates are [9.011, 9.078] and [11.515, 11.581]. This finding shows that the threshold value of innovation activity on the talent agglomeration scale for economic structure optimization is greater than the threshold value for economic efficiency improvement.

In addition, this article plots the likelihood ratio function to reflect the estimation and confidence interval construction process of the innovation activity threshold of the talent agglomeration scale for high-quality economic development. Fig. 2a and b describe the effect of the construction process of the innovation activity threshold value of the talent agglomeration scale on economic efficiency improvement and basic estimated structural optimization, respectively. The dotted line in the figure represents the critical value of the likelihood ratio (LR) statistic at the 5 % significance level (value 7.35). It can be seen from the figure that when LR = 0, the corresponding threshold values of the talent agglomeration scale are approximately 9.059 and 11.571. When the thresholds are within the corresponding 95 % confidence intervals, the LR is less than 7.35. Therefore, it can be concluded that the critical estimate of the talent concentration scale for high-quality development passes the authenticity test.

The regression results of the threshold effect of the talent agglomeration scale on the impact of high-quality economic development

Table 3
Threshold effect test of the talent agglomeration scale.

Explained variable	Model	F-value	P-value	Threshold Estimators	95 % Confidence intervals	Threshold value		
						1 %	5 %	10 %
EEI	Single threshold	61.38	0.000	9.059	[9.011,9.078]	35.756	40.727	46.773
	Double threshold	16.88	0.515	9.059,10.890	[9.011,9.078], [10.659,10.949]	30.619	34.134	42.266
	Triple threshold	17.23	0.148	8.466	[8.253,8.486]	18.677	21.788	30.255
ESO	Single threshold	57.97	0.000	11.571	[11.515,11.581]	26.739	26.542	31.920
	Double threshold	10.17	0.210	11.571,12.022	[11.515,11.581], [11.927,12.089]	11.485	13.216	18.321
	Triple threshold	16.37	0.443	11.002	[10.977,11.020]	33.169	40.740	56.260

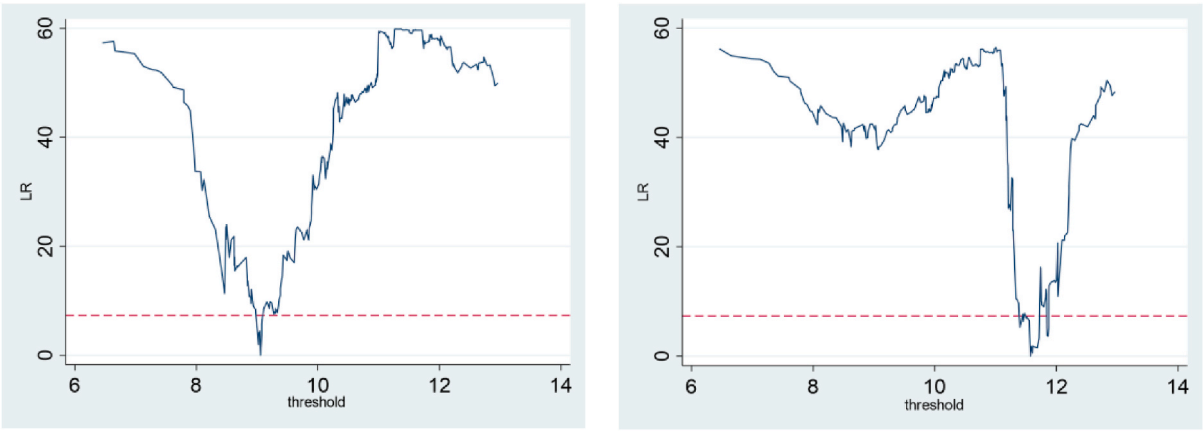

Fig. 2. a) Likelihood ratio function plot for a threshold of 9.059. b) Likelihood ratio function plot for a threshold of 11.571.

with innovation activity as the threshold variable are shown in Table 4. Model (7) shows that when the innovation activity value is lower than 9.059, the impact coefficient of the talent agglomeration scale on economic efficiency improvement is 0.754. The results pass the significance test at the 1 % level. When innovation activity is higher in value than 9.059, the positive effect of the talent agglomeration scale on economic efficiency improvement still passes the significance test, but the impact coefficient decreases (0.413 < 0.754). This finding indicates that with increasing innovation activity, the positive effect of the talent agglomeration scale on economic efficiency improvement weakens. Similarly, from Model (8), it can be seen that as innovation activity crosses the threshold value of 11.571, the contribution of the talent agglomeration scale to economic structure optimization gradually decreases (4.582 < 8.804). These findings suggest that the talent agglomeration scale significantly aids in enhancing economic efficiency and optimizing the economic structure, irrespective of the level of innovation activity. Nonetheless, when the level of innovation activity surpasses the threshold, the coefficients of the impact of the talent agglomeration scale on economic efficiency improvement and economic structure optimization tend to diminish, which indicates that the talent agglomeration scale has a positive yet decreasing marginal utility impact on high-quality economic development. The above analysis robustly supports Hypothesis 2.

To comprehensively analyze the effect of the threshold characteristics of the talent concentration scale on high-quality economic development in different regions, this paper analyzes the distribution of relative threshold values of innovation activity in 30 provincial regions in China in 2011 and 2020. The high threshold interval (INNOV >11.571), medium threshold interval (9.059<INNOV≤11.571), and low threshold interval (INNOV≤9.059) of innovation activity are derived. The 30 regions and their different threshold ranges for innovation activity are shown in Table 5.

As shown in Table 5, first, the high threshold interval (INNOV >11.571) increases from 10 % in 2011 to 36.66 % in 2020, and the medium threshold interval (9.059<INNOV≤11.571) increases from 36.67 % to 56.66 %, which indicates that overall innovation activity in China is gradually optimizing. However, combined with the results in Table 4, the marginal effect of the talent agglomeration scale decreases with increasing innovation activity. For provinces in the interval between the high and medium thresholds, moving forward, it is not only necessary to win the "war for talent" through advantages such as household registration and the social security system but also essential to stimulate acquired talent to play a more significant role after being acquired, thereby achieving a *qualitative change from quantitative change*. In fact, some regions have already begun to address this issue. For instance, in November 2019, in the "Implementation Plan for the Reform of Natural Science Researchers", talent classification and evaluation were proposed for Guangdong Province, which served to expedite the construction of the scientific research staff. Such an approach plays a crucial role in establishing the correct employment orientation, stimulating enthusiasm for talent innovation, and fully unleashing the

Table 4
Threshold regression results for the talent agglomeration scale.

variable	EEI		variable	ESO	
	Model (7)			Model (8)	
	Coefficients	t		Coefficients	t
PGDP	0.141**	2.39	PGDP	4.377***	3.80
INFR	−0.010	−0.34	INFR	−2.652***	−4.59
FDI	−0.593***	−19.82	FDI	0.288	0.30
MARK	0.241***	16.96	MARK	3.053***	8.00
INNOV≤9.059	0.754***	13.57	INNOV≤11.571	8.804***	10.27
INNOV >9.059	0.413***	12.22	INNOV >11.571	4.582***	5.01
Constant	9.073***	23.73	Constant term	−24.029*	−1.71
R^2	0.932		R^2	0.816	

Note: *, **, *** denote $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 5
Distribution of relative thresholds of innovation activity in 30 provincial regions in 2011 and 2020.

Threshold interval	2011	2020
INNOV≤9.059	Shanxi, Inner Mongolia, Jilin, Jiangxi, Guangxi, Hainan, Chongqing, Guizhou, Yunnan, Gansu, Qinghai, Ningxia, Xinjiang	Hainan, Qinghai
9.059<INNOV≤11.571	Beijing, Tianjin, Hebei, Liaoning, Heilongjiang, Shanghai, Anhui, Fujian, Shandong, Henan, Hubei, Hunan, Sichuan, Shaanxi	Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangxi, Hunan, Guangxi, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Ningxia, Xinjiang
INNOV >11.571	Jiangsu, Zhejiang, Guangdong	Beijing, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Shandong, Henan, Hubei, Guangdong, Sichuan

dividend of talent effectiveness. However, throughout this process, attention must be given to the optimization of the evaluation index as development progresses. The assessment threshold should also be raised appropriately at the correct time, which would encourage and guide different types of talent in combining their accumulated advantages, thereby contributing to the high-quality economic development of each region.

Second, the percentage of regions in the low threshold range (INNOV≤9.059) decreases from 43.33 % in 2011 to 6.67 % in 2020. As of 2020, the only two provinces with innovation activity in the low range are Hainan and Qinghai. Combined with Table 4 above, it can be found that when innovation activity is in the low threshold range, the talent agglomeration scale contributes the most to high-quality economic development. Therefore, for Hainan and Qinghai, the positive effects of the talent agglomeration scale on economic efficiency improvement and economic structure optimization are greatest.

(2) Results of threshold regression analysis of the effect of the talent agglomeration effectiveness on high-quality economic development

Repeating the above test method, we can obtain the test results of the threshold effect of talent agglomeration effectiveness on high-quality economic development with innovation activity as the threshold variable (see Table 6). When the explained variable is economic efficiency improvement, there is only a single threshold of 9.336; when the explained variable is economic structure optimization, there is a double threshold of 10.977 and 11.571. The 95 % confidence interval formed by the efficiency of talent agglomeration on the improvement of economic efficiency is [9.102, 9.368]; the confidence interval formed by the efficiency of talent agglomeration on the optimization of economic structure is [10.878, 10.977] and [11.530, 11.581].This result mirrors that of the talent agglomeration scale, wherein the threshold value of talent agglomeration effectiveness on economic structure optimization exceeds the threshold value on economic efficiency improvement (10.977,11.571 > 9.336). This suggests that a higher level of innovation activity is necessary to attain high-quality economic development, particularly economic structure optimization, by harnessing the talent agglomeration effect.

Similarly, this paper also plots the likelihood ratio function to reflect the estimation and confidence interval construction process of talent agglomeration effectiveness on the innovation activity threshold for high-quality economic development. Fig. 3a and b describe the effect of the construction process of the innovation activity threshold value of talent agglomeration effectiveness on economic efficiency improvement and economic structure optimization, respectively. It can be seen from the figure that when LR is equal to 0, the critical estimated value of talent agglomeration effectiveness for improving economic efficiency is about 9.059; the critical estimated value for economic structure optimization is approximately 10.977 and 11.571. When the threshold values are within the corresponding 95 % confidence intervals, the LR is less than 7.35. Thus it can be considered that the threshold estimates are consistent with the actual values, i.e., the threshold values of talent agglomeration effectiveness on high-quality economic development pass the authenticity test.

The regression results of the threshold effect of the talent agglomeration effectiveness on the impact of high-quality economic development with innovation activity as the threshold variable are shown in Table 7. Model (9) illustrates that as innovation activity value surpasses the threshold, the effect of talent agglomeration effectiveness on economic efficiency improvement passes the significance test at the 1 % level. However, its impact coefficient decreases from 2.249 to 1.302. This suggests that a continuous increase in innovation activity does not invariably enhance talent agglomeration effectiveness, i.e., there is a diminishing marginal effect of the

Table 6
Threshold effect test of the talent agglomeration effectiveness.

Explained variable	Model	F-value	P-value	Threshold Estimators	95 % Confidence intervals	Threshold value		
						1 %	5 %	10 %
EEI	Single threshold	14.03	0.000	9.336	[9.102,9.368]	6.929	7.597	8.973
	Double threshold	3.52	0.780	6.983,9.305	[6.455,7.276], [9.064,9.368]	7.206	8.208	9.775
	Triple threshold	3.15	0.777	11.077	[11.020,11.109]	9.374	10.833	13.754
ESO	Single threshold	32.43	0.000	10.977	[10.878,10.977]	21.505	22.351	25.425
	Double threshold	31.10	0.005	10.977,11.571	[10.878,10.977], [11.530,11.581]	20.381	22.025	25.804
	Triple threshold	20.24	0.997	9.059	[8.629,9.078]	58.822	65.882	74.249

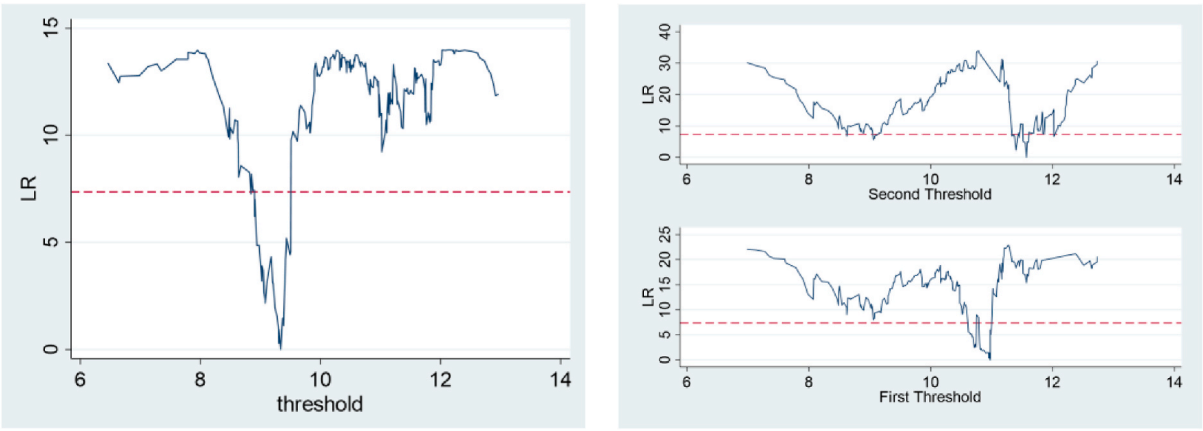

Fig. 3. a) Graph of the likelihood ratio function with a threshold of 9.336. b) Graph of the likelihood ratio function with a threshold of 10.977 and 11.571.

threshold effect of innovation activity.

From Model (10), it is observable that the coefficient of the effect of talent agglomeration effectiveness on economic structure optimization shifts from positive to negative as innovation activity progressively increases. Moreover, the coefficient of talent agglomeration effectiveness on economic structure optimization only passes the significance test when the innovation activity falls within the range of 10.977–11.571. This finding suggests that excessively high or low innovation activity cannot fully catalyze the talent agglomeration effectiveness. There exists an optimal interval of innovation activity, within which the talent agglomeration effectiveness exerts its maximum influence on promoting economic structure optimization. Hypothesis 3 is partially supported.

In this paper, we take into account the different characteristics of innovation activity in the promotion of talent agglomeration effectiveness on high-quality economic development. Below is an analysis of the relative threshold value distribution of innovation activity in 30 provinces in China in 2011 and 2020, as shown in Table 8.

As shown in Table 8, the number of provincial regions within the intervals of INNOV >11.571 and 10.977< INNOV≤11.571 both show an increasing trend, reaching a total of 66.67 % of the country as of 2020. Among them, regions with 10.977< INNOV≤11.571 increase from 13.3 % in 2011 to 30 % in 2020. In this interval, the positive impact coefficient of talent agglomeration effectiveness on economic structure optimization is the largest, and it also is shown to significantly contribute to economic efficiency improvement. That is, when innovation activity is within the range of 10.977<INNOV≤11.571, the efficiency of talent agglomeration has the most potent positive effect on high-quality economic development. Therefore, if regions want to realize high-quality economic development through talent agglomeration effectiveness, then they should maintain a high level of innovation activity.

When INNOV≤9.336 and 9.336<INNOV≤10.977, the effectiveness of talent agglomeration contributes significantly to the enhancement of economic efficiency, although it does not considerably contribute to structural optimization. Regions falling within these two intervals, including Qinghai, Ningxia, and Inner Mongolia, are located primarily in western China. The observed result may be attributed to the continued outward expansion of the siphon effect in eastern and central China due to the concentration of high-quality resources. Moreover, the relative scarcity of resources in western China, in comparison with that in eastern and central China, results in a spillover of innovation resource elements, leading to a more pronounced crowding-out effect of talent agglomeration effectiveness in western China than the incentivizing effect. Therefore, in the future, western China could attract talent by offering certain living and housing subsidies, as well as tax concessions and other policy dividends [16]. Simultaneously, western China should

Table 7
Threshold regression results for the talent agglomeration effectiveness.

variable	EEI		variable	ESO	
	Model (9)			Model (10)	
	Coefficients	t		Coefficients	t
PGDP	0.258***	4.05	PGDP	9.200***	7.51
INFR	−0.208***	−7.96	INFR	−4.355***	−7.29
FDI	−0.719***	−23.98	FDI	2.140***	1.97
MARK	0.398***	32.32	MARK	2.423***	4.43
INNOV≤9.336	2.249***	10.97	INNOV≤10.977	2.338	0.48
INNOV >9.336	1.302***	4.41	10.977< INNOV≤11.571	77.736***	6.38
			INNOV > 11.571	−7.120	−0.41
Constant	11.022***	31.41	Constant term	−43.045***	−2.73
R^2	0.917		R^2	0.779	

Note: *, **, *** denote $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Table 8
Distribution of relative thresholds of innovation activity in 30 provinces in 2011 and 2020.

Threshold interval	2011	2020
INNOV≤9.336	Shanxi, Inner Mongolia, Jilin, Jiangxi, Guangxi, Hainan, Guizhou, Yunnan, Gansu, Qinghai, Ningxia, Xinjiang	Hainan, Qinghai, Ningxia
9.336<INNOV≤10.977	Tianjin, Hebei, Liaoning, Heilongjiang, Anhui, Fujian, Hubei, Hunan, Chongqing, Sichuan, Shaanxi	Shanxi, Inner Mongolia, Guangxi, Guizhou, Yunnan, Gansu, Xinjiang
10.977< INNOV≤11.571	Beijing, Shanghai, Shandong, Henan	Tianjin, Hebei, Liaoning, Jilin, Heilongjiang, Jiangxi, Hunan, Chongqing, Shaanxi
INNOV >11.571	Jiangsu, Zhejiang, Guangdong	Beijing, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Shandong, Henan, Hubei, Guangdong, Sichuan

construct a development platform to retain talent and actively release the positive feedback effect of talent gathering. This approach would allow for a better combination of local development and talent development, thereby forming the optimal pairing mode of talent gathering and economic development.

Based on the analysis of the results in Tables 5 and 8, it can be inferred that regions can initially maintain a low level of innovation activity and enhance the scale of talent agglomeration through policies such as talent introduction. However, in the long term, it is imperative to stabilize innovation activity at higher levels to boost talent agglomeration effectiveness. Hence, for China, optimizing the talent aggregation mechanism and leveraging the talent aggregation effect remain significant areas that require improvement. Regions should persist in commencing from actual local economic development and talent demand and establish institutional mechanisms that align with the principles of local economic development and talent growth. To foster the positive interaction of innovation factors, regions should also fully unleash the leader effect of all types of talent. Ultimately, China should form a system involving graded talent grading and regional comparative advantages, thereby more effectively promoting high-quality economic development.

5. Conclusions and implications

5.1. Discussion

Using panel data from 2011 to 2020 across 30 provincial-level regions in China, this paper empirically investigates the impact of talent agglomeration on high-quality economic development using a benchmark regression model. Additionally, by employing threshold regression models, this work examines the nonlinear effects of talent agglomeration on high-quality economic development under varying levels of innovation activity. The main conclusions drawn from the analysis are presented below.

First, this paper confirms the positive effect of talent agglomeration on high-quality economic development. On the one hand, the talent agglomeration scale can significantly promote high-quality economic development; on the other hand, talent agglomeration effectiveness plays a significant role in promoting economic efficiency, but the promotion of economic structure optimization does not pass the significance test. These findings are consistent with those of a previous study by Xu and Wu [14]. There may be multiple reasons for these results. First, economic efficiency improvement is often directly related to increasing productivity and improving resource allocation, which are areas that can be directly influenced by talent effectiveness. By promoting knowledge sharing, technological innovation and learning effects, talent effectiveness can improve productivity and the overall performance of economic activities, which in turn contributes to economic efficiency improvement. Second, the optimization of the economic structure is a complex process that involves not only industrial upgrading but also interactions between industries and the reconfiguration of resources among different industries [38]. These processes may be affected by a variety of factors, such as market demand, the policy environment and international competition, and the impact of talent concentration may be masked by other factors, making its role difficult to accurately measure.

Second, when innovation activity is used as the threshold variable, the talent agglomeration scale has a diminishing marginal effect on high-quality economic development. Specifically, when the value of innovation activity is less than 9.059, the talent agglomeration scale has a significant impact on the improvement of economic efficiency. When the value of innovation activity is less than 11.571, the same agglomeration scale significantly affects economic structure optimization. However, once innovation activity exceeds these thresholds, the positive impact of the talent agglomeration scale on economic efficiency improvement and economic structure optimization begins to weaken. This situation may be due to the fact that in an environment with high innovation activity levels, other factors, such as digital technology innovation, capital investment or policy support, may play a more important role. In addition, talent agglomeration exceeding a certain threshold may lead to problems such as the uneven distribution of resources and increased costs. These problems themselves may inhibit economic efficiency improvement and further economic structure optimization. This view is also supported by Yang [39]. Therefore, policy-makers need to carefully consider the actual level of innovation activity when promoting talent agglomeration policies to ensure that the scale of talent agglomeration can maximize its effectiveness in promoting economic development.

Finally, this paper highlights that talent agglomeration effectiveness has a nonlinear impact on high-quality economic development through innovation activeness. First, this paper reveals that the impact of talent agglomeration effectiveness on economic efficiency improvement is constrained by a single innovation activity threshold of 9.305. When innovation activity exceeds this threshold, the positive impact of talent agglomeration on economic efficiency improvement starts to weaken. This phenomenon may occur because increased innovation activity introduces a larger number of innovative factors and technological advances. In particular, the

widespread use of digital technologies has led to profound changes in the way work and production are carried out. The spread and convenience of digital tools have also made it easier for individuals and firms to access the required expertise and skills. To some extent, these factors have reduced the level of reliance on pooled talent, thereby reducing the marginal contribution of talent agglomeration effectiveness [40]. Second, for economic structure optimization, talent agglomeration effectiveness is influenced by two innovation activity thresholds, namely, 10.977 and 11.571. Within the range defined by these thresholds, talent agglomeration effectiveness significantly contributes to the optimization of the economic structure. This finding suggests that within a specific interval of innovation activity, talent agglomeration effectively promotes the development of a more efficient and advanced economic structure through knowledge innovation and technology application [6]. However, when the innovation activity level falls below 10.977 or surpasses 11.571, the positive effect of talent effectiveness on economic structure optimization becomes nonsignificant. This finding can be attributed to the dominance of other factors, such as market dynamics or industry maturity, outside of these intervals, which assume a pivotal role in driving the optimization of the economic structure.

5.2. Practical implications

The findings of this paper have the below implications.

First, each region should strive to balance the importance of talent introduction and cultivation, thereby creating an environment conducive to talent agglomeration. All regions should enhance the construction of talent systems; advance system innovations, including talent introduction, management, and mobility; and establish the principle of "appointing talent based on their capacity and optimizing their utilization" [41] (p. 69). It is essential not only to maximize efforts to increase the scale of talent agglomeration but also to fully leverage the efficiency of talent agglomeration. Moreover, it is necessary to not only attract talent but also nurture and utilize talent, thereby promoting the effective gathering of innovative resources. These efforts can create a talent-driven city, adding new vitality and momentum to high-quality economic development.

Second, each region should accurately pinpoint the demands of economic development and adjust its regional innovation activity level at the appropriate juncture. Regions should deeply implement innovation-driven development strategies and boldly innovate models of production factor agglomeration. Initially, regions can start with a low level of innovation activity to enhance the scale dividend of talent concentration. Simultaneously, they should vigorously cultivate innovation subjects and construct various innovation platforms, thereby continuously enhancing the leading and supporting role of science and technological innovation in economic development. Subsequently, regions should actively release the dividend of talent agglomeration effectiveness with higher innovation activity levels. This approach will promote the transformation of old and new dynamics and infuse vitality into robust economic development.

Third, between regions, it is essential to dismantle regional institutional barriers and foster the reasonable flow of talent resources. China should address the imbalance in its economic development levels caused by regional talent imbalances and eliminate the administrative and institutional barriers that constrain the development of regional synergy [39]. Each region should not only form a cross-regional and cross-field talent gathering platform based on digital technology with online and offline two-way linkages but also create comprehensive talent service chains. This approach will continuously promote the smooth flow of talent between different regions and realize the intellectual sharing of talent resources, thereby fostering the healthy and sustainable development of China's economy.

5.3. Limitations and future perspectives

While this study makes certain advancements, it nonetheless has several limitations. First, this paper explores the influence of talent agglomeration on the high-quality development of the economy, without verifying specific action paths. Future research can delve into the mediating mechanisms between the two to offer more comprehensive theoretical guidance for achieving high-quality economic development. Second, although we construct a threshold regression model to examine the relationship between talent agglomeration and high-quality economic development under different levels of innovation activity, other factors may also affect this relationship. We should realize the complexity of economic development, and thus, future research can further apply threshold regression models to explore the impact of other factors, such as industrial structure upgrades and social culture, on the connection between talent agglomeration and high-quality economic development. Finally, this paper exclusively utilizes regional data from 30 provinces in China, potentially limiting the generalizability of the findings. Therefore, subsequent research could expand the sample size and consider the global perspective when examining the impact of talent pooling on economic development to mitigate the limitations of the present study.

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Data availability statement

The data presented in this study are available on request from the corresponding author.

CRediT authorship contribution statement

Xiaojie Jian: Writing – review & editing, Writing – original draft, Supervision, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Danli Du:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Dezhi Liang:** Writing – review & editing, Methodology, Software, Visualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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