Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

Research on Human Capital Gradient Upgrading Based on Innovation Development

Wei Wang[1], Yingzhe Wang[1]*, Ping Li[2]
[1]School of Public Finance and Administration, Harbin University of Commerce, Heilongjiang, Harbin, China
[2]Labor Economics, College of Business, Quzhou University, Zhejiang, Quzhou, China
*Corresponding Author.

Abstract:

The core of high-quality economic development is to realise the innovation-driven development strategy, and the decisive factor for innovation development is to realize the gradient upgrade of human capital. By refining the human capital gradient upgrading into industry allocation gradient and quality structure gradient, the mechanism of the impact of human capital gradient upgrading on innovation development is sorted out by analysing the hindrance of innovation development. Firstly, the gradient of human capital quality structure effectively promotes innovation development, while the mismatch of human capital industry allocation hinders innovation development. Secondly, the impact of the advanced human capital structure on innovation development is non-linear, and there is a threshold effect of the gradient of the human capital quality structure reaching a certain threshold that hinders innovation development, mainly based on the "erosion effect" and the inverse impact of dry schooling, educational lag , and gradient leap; given a given level of human capital quality structure, there is regional heterogeneity in the allocation of human capital sectors on innovation development. Finally, there is regional heterogeneity in innovation development, which is the result of a combination of policy orientation and income disparity.

Keywords*: Innovation development, Human capital, Gradient upgrading, Threshold effect, Mediating effect, Double differencing.*

I. INTRODUCTION

In the context of the structural deceleration of economic growth and the transformation and development of the economy to high quality, the high-quality development of innovation, coordination, green, openness and sharing has gradually become the theme of the times, the core of which is the comprehensive promotion of the innovation-driven development strategy

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

and the new development pattern of further enhancing the capacity of independent innovation [1]. The 14th Five-Year Plan proposes to adhere to the core of innovation in the overall situation of China's modernization status, strengthen the cultivation of innovative, applied and skilled talents, and improve the evaluation system of scientific and technological talents oriented to innovation ability, quality, effectiveness and contribution. This indicates that high-quality development has become the way forward for China's economic development, as well as a new idea, a new concept, a new goal and a new journey to guide the new period, while human capital and innovation, as the two carriages that drive China's new development approach side by side, are inextricably linked, and talents are the promoters and practitioners of innovation[2] and innovation itself is the embodiment of value-added human capital [3].

China's regional innovation efficiency at this stage is at the stage of weak returns to scale[4], on the one hand, the overall workforce's education level is low[5], and the proportion of high-level human capital in the third gradient is low, which shows heterogeneity depending on the stage of economic development and the type of industry; on the other hand, there is a mismatch between the industry allocation of human capital and the level of education and On the other hand, there is a mismatch between the industry allocation of human capital and the level of education and academic specialization it receives[6], and human capital gradually forms a vertical and precipitated state among industries[7], and there are industry differences in the synergy effect with innovation development[8]. Based on this, this paper subdivides the human capital gradient into industry allocation gradient and quality structure gradient, comprehensively analyzes the influence mechanism of human capital gradient upgrading on innovation development, designs the optimization path of scientific human capital quality structure and diversified human capital industry allocation, and forms a coherent chain between human capital gradient upgrading and innovation development to ensure a virtuous cycle of high-quality economic development.

II. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

At the macroeconomic level, human capital is considered as an important determinant of innovation[9], and human capital promotes an increase in the quantity and quality of innovation in firms[10]; at the microeconomic level, based on the alternative view of human capital[11], which considers highly skilled human capital as a key dimension of firms' innovation process[12]; in the field of industrial economics, the impact of human capital as a key resource on firms' innovation is somewhat heterogeneous, mainly based on city size [13], number of patents[14] and other factors.

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

On the one hand, the advanced human capital structure is conducive to improving the efficiency of industrial innovation[15], the process of human capital deepening is the increase of the average years of education of the workforce and the increase of the proportion of highly educated workforce in the overall workforce[16], and the professional skills and knowledge developed in this process are conducive to improving the capacity of independent innovation[17] and the higher the level of human capital the greater the impact of the group on the innovation capacity of the city [18].

On the other hand, human capital is influenced by industry to innovate, and science and technology human capital is more decisive for technological innovation[19], human capital mismatch is manifested as a mismatch between human capital levels and job levels[20], human capital scarcity in the competitive sector and human capital redundancy in the government public sector and monopoly sector co-exist[21], the rise of science and technology human resources and R&D investment both significantly reduce the innovation risk of enterprises[22], and as the proportion of science and technology managers and science and technology R&D personnel increases, innovation efficiency shows a trend of first increasing and then decreasing[23].

The literature has focused on the impact of human capital gradient upgrading, advanced human capital structure or talent allocation on innovation development, while at this stage human capital gradient upgrading and human capital advanced have not been clearly defined and distinguished, this paper regards human capital advanced as part of human capital gradient upgrading, refines human capital gradient upgrading into quality structure gradient and industry allocation gradient, and develops for the characteristics of both The mechanism of the impact on innovation development is analysed. This leads to hypotheses 1 and 2.

Hypothesis 1: Structural gradient upgrading of human capital quality effectively promotes innovation development.

Hypothesis 2: The human capital industry mismatch problem hinders innovation development.

Based on the verification of endogenous growth theory, the knowledge and skills of human capital owners lead to differences in the productivity allocation of workers, so human capital heterogeneity leads to significant variability in industrial innovation, and there is a significant U-shaped relationship between talent and enterprise innovation speed[24] and a significant inverted N-shaped relationship with the innovation efficiency of university science and technology innovation[25]. The positive contribution of science and technology finance to

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

regional innovation efficiency is predicated on the level of human capital reaching a threshold level[26]. And given a given level of human capital quality structure, there is regional heterogeneity in human capital industry allocation to innovation development, with policy and regulatory orientations, natural endowments, historical conditions, local market demand and industrial agglomeration being important influencing factors for such large regional differences in human capital accumulation to innovation output [27].

Based on the analysis of the literature, it can be seen that the trend of human capital quality structure gradient on innovation development is mostly non-linear, so it is assumed that there is a threshold effect, where the level of human capital reaches a certain threshold but hinders innovation development. In addition, the impact of the human capital industry allocation gradient on innovation development is regionally heterogeneous, as the industry choice of talent is constrained by local policies and regulations, so it is assumed that local policies and regulations will have an impact on the industry allocation of human capital, thus affecting innovation development. Based on the above analysis the research hypotheses that summarise the impact of upgrading the human capital gradient on innovation development. This leads to hypotheses 3 and 4.

Hypothesis 3: There is a threshold effect on the impact of advanced human capital structure on innovation development.

Hypothesis 4: The impact of human capital industry allocation on innovation development is affected by local policy and regulation shocks.

III. MEASUREMENT MODEL DESIGN AND INDICATOR CONSTRUCTION

3.1 Basic Regression Model Design

Based on the above analysis and hypothesis 1 and hypothesis 2, the basic regression model of the impact of upgrading the human capital gradient on innovation development is constructed, with regional innovation development as the explanatory variable, and human capital industry allocation gradient and human capital quality structure gradient as the core explanatory variables, and the following econometric equations are constructe.

$$Ln\_patent_{it} = \alpha_1 H\_qual_{it} + \alpha_2 H\_allo_{it} + \alpha_3 X_{it} + \alpha_0 + \varepsilon_{it} \quad (1)$$

Where $H\_qual(it)$ denotes the gradient upgrading index of human capital quality structure at time t and region i, $H\_allo(it)$ denotes the gradient upgrading index of human capital

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

sectoral allocation at time t and region i; Ln_patent_{it} is innovation development, X_{it} is a series of control variables are R&D funding Ln_RD_{it}, R&D input intensity RD_ratio_{it}, research level Ln_paper_{it}, research capability $Ln\_literature_{it}$ and innovation environment $Ln\_enterprise_{it}$, $\alpha_0, \alpha_1, \alpha_2, \alpha_3$ is the parameter to be estimated, and ε_{it} is the error term of randomness factor.

3.2 Threshold Effect Model Design for Structural Gradients in Human Capital Quality

The threshold effect refers to the phenomenon that when one economic parameter reaches a specific value, it causes another economic parameter to undergo a sudden shift to other forms of development. In order to further analyse the mechanism of the influence of the gradient of human capital quality structure on innovation development and to test the non-linear dynamic mechanism of the effect of upgrading the gradient of human capital quality structure on innovation development, with reference to Hansen (1999)[28] and based on hypothesis 3. A single panel threshold model is constructed as follows.

$$Ln\_patent_{it} = \beta_1 H\_qual_{it} \times I(r_{it} \le \theta) + \beta_2 X_{it} \times I(r_{it} > \theta) + \beta_0 + \varepsilon_{it} \quad (2)$$

Where θ is the threshold to be estimated, $I(\square)$ is an indicative function with a value of 1 or 0, $\beta_0, \beta_1, \beta_2$ are the parameters to be estimated and r_{it} are the threshold variables, and the human capital quality structural gradient itself is chosen as the threshold variable in this paper.

3.3 A Double Difference Model Design for the Allocation Gradient of Human Capital Industries

There is regional heterogeneity in the impact of human capital industry allocation gradient on innovation development, the reason for this is that the choice of talent industry may be influenced by policy orientation. in order to more robustly assess the impact of upgrading human capital industry allocation gradient on regional innovation development, it is necessary to consider the impact of relevant external environmental factors, based on hypothesis 4 using double difference model for further analysis. on 31 August 2014, the The Decision on the Establishment of Intellectual Property Courts in Beijing, Shanghai and Guangzhou was adopted at the 10th meeting of the Standing Committee of the 12th National People's Congress [29].

Through the implementation of the Decision, the Beijing, Shanghai and Guangdong regions have generated positive impetus in protecting the interests of IPR owners and promoting the construction of the IPR legal system, further accelerating the gradient upgrading of human

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

capital industry allocation and encouraging innovation development. Referring to Zhao Tao (2020) [30], the conditions for the realisation of the effect of shocks are first judged, and a mediating effects model is used to test whether the Decision will achieve innovation development through the gradient upgrading of human capital industry allocation, and then the effect of shocks is verified based on a double-difference model.

$$Ln\_patent_{it} = \lambda_1 H\_allo_{it} + \lambda_2 X_{it} + \lambda_0 + \varepsilon_{1it} \quad (3)$$

$$group_{it} = \mu_1 H\_allo_{it} + \mu_2 X_{it} + \mu_0 + \varepsilon_{2it} \quad (4)$$

$$Ln\_patent_{it} = \lambda_1' H\_allo_{it} + \pi group_{it} + \lambda_2' X_{it} + \lambda_0' + \varepsilon_{3it} \quad (5)$$

$$Ln\_patent_{it} = \gamma_1 group_{it} + \gamma_2 X_{it} + \gamma_0 + \varepsilon_{it} \quad (6)$$

Where λ_1, μ_1, π, λ_1' and γ_0, γ_1, γ_2 are the parameters to be estimated . e_1, e_2, e_3 are the regression residuals. $group_{it}$ are dummy variables: Beijing, Shanghai and Guangdong are set as the experimental group after 2014 and take the value of 1; Beijing, Shanghai, Guangdong and other provinces in 2014 and previous years are the control group and take the value of 0.

3.4 Human Capital Gradient Index Measurement

Human capital gradient upgrading refers to the process of optimizing human capital in a stepped structure, and the process of human capital quality structure gradient upgrading can be regarded as the process of human capital advanced, i.e. human capital at lower levels is optimized to higher levels step by step. Taking the industrial structure upgrading index as a reference and drawing on Zhang Nan(2020)[20] to construct alternative indicators for the gradient upgrading of human capital quality structure, the process of gradient upgrading of human capital quality structure can be regarded as the process of human capital advanced, i.e. the leap of talents from lower to higher levels, setting the human capital with higher education level as the number of workers with college and above education, the human capital with lower education level as The number of workers with high school education and below, and the weighted ratio of the working population at each level is the gradient upgrading index of human capital quality.

$$H\_qual(it) = \sum H_h(it) \Big/ \sum H_l(it) \quad (7)$$

$H\_qual(it)$ denotes the gradient upgrading index of the quality structure of human capital at time t and region i. $H_h(it)$ denotes the number of working population at each level of

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

tertiary education and above, and $H_l(it)$ denotes the number of working population at each level of high school education and below, data source: China Population and Employment Statistical Yearbook.

Based on the industry classification by factor intensity by Lu Tong (2014)[31] and with reference to the detailed classification of manufacturing industries by Yang Ligao (2018)[32], the industries are divided into those with high technology intensity (technology-intensive) and those with low technology intensity (labour-intensive), and based on the measurement of the gradient of human capital quality structure, the gradient of human capital industry allocation can be set as The ratio of the total population of workers in labour-intensive industries to the total population of workers in technology-intensive industries.

$$H\_allo(it) = \sum H_d(it) \Big/ \sum H_g(it) \tag{8}$$

$H\_allo(it)$ denotes the gradient upgrading index of human capital industry allocation at time t and region i. $H_d(it)$ denotes the number of working population in labour-intensive industries and $H_g(it)$ denotes the number of working population in technology-intensive industries, data source: China Labour Statistics Yearbook.

3.5 Variable Descriptions and Data Sources

This paper selects panel data for 31 provinces, cities and autonomous regions in mainland China from 2009 to 2019, with the original data sources being the China Statistical Yearbook, the China Statistical Yearbook of Science and Technology, the China Statistical Yearbook of Labour, and the China Statistical Yearbook of Population and Employment, with the variable names and statistical descriptions shown in Table I.

TABLE I. Statistical description of variables

Variable Code	Variable Name	MEAN	SD	MIN	MAX	MEDIAN
Ln _ patent	Innovative development (logarithm of patent applications)	6.34	1.42	1.95	9.78	6.47
H _ allo	Human capital industry allocation	4.69	2.44	1.22	15.36	4.29

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

	gradient					
H _ qual	Structural gradient of human capital quality	0.24	0.22	0.00	1.65	0.18
Ln _ RD	R&D funding taken as logarithm	5.22	1.55	0.14	1.65	5.37
RD _ ratio	R&D input intensity (%)	1.60	1.11	0.19	6.31	1.32
Ln _ paper	Research level (logarithm of the number of published papers)	8.02	1.01	4.72	11.07	8.09
Ln _ literature	Scientific research capacity (logarithm of the number of published monographs)	4.42	0.98	1.10	7.86	4.44
Ln _ enterprise	Innovation environment (logarithm of the number of high technology enterprises)	5.90	0.98	1.61	9.16	6.22

IV. EMPIRICAL ANALYSIS

4.1 Analysis of Basic Regression Results

Based on regional panel data from 2006 to 2019, the econometric benchmark regression model (2.1) was analysed using stata15.1 software, and the econometric results are shown in Table II(1), with the inclusion of control variables shown in Table II(2).

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

TABLE II. Baseline regression results

Variable Code	(1)	(2)
	Ln _ patent	*Ln _ patent*
H _ allo	-0.1820638***	-0.06212***
	(0.0261745)	(0.0189178)
H _ qual	2.877051***	0.7435696***
	(0.2860998)	(0.2740717)
Ln _ RD		0.6568533***
		(0.069589)
RD _ ratio		-0.1757377**
		(0.0696691)
Ln _ paper		0.9439393***
		(0.0739949)
Ln _ literature		-0.1669341***
		(0.0618584)
Ln _ enterprise		-0.3102428***
		(0.0698004)
_cons	6.511409***	-1.70885***
obs	341	310
R-squared	0.3861	0.8901

Note. * , * * , * * * indicates significant at the 10%, 5% and 1% levels respectively and values in brackets are standard errors

As the number of population in technology-intensive industries is low in individual provinces, the ratio of the number of labour force in technology-intensive and labour-intensive industries is too small for further analysis, so the ratio of labour force in labour-intensive and technology-intensive industries is chosen as the human capital industry allocation gradient variable in this paper. The human capital industry allocation gradient indicator has a negative effect on innovation development.

According to the results of the baseline regression analysis without the inclusion of control variables in Table II(1), it can be seen that the coefficients of the human capital industry allocation gradient and the human capital quality structure gradient are -0.18 and 2.88 respectively, and are significant at the 1% level, indicating that the upgrading of the human capital gradient has a significant impact on innovation development, and Hypothesis 1 and Hypothesis 2 hold; according to the results of the regression with the inclusion of control variables in Table II(2), it can be seen that The coefficients of the two are -0.06 and 0.74 respectively and significant at the 1% level, hypothesis 1 and hypothesis 2 still hold, but the coefficients have been reduced, indicating that other control variables also affect innovation

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

development to some extent.

According to the results of the econometric tests of hypothesis 1 and hypothesis 2, it can be seen that the mismatch between human capital and innovation development is mainly reflected in the mismatch between the level of human capital and the level of jobs, that is, the mismatch between the gradient of human capital quality structure and the gradient of industry allocation and the demand for innovation development. The so-called mismatch is relative to the equilibrium state of resource allocation. The imperfect development of factor markets and the obstruction of the flow and effective allocation of factors lead to the deviation of resource allocation from equilibrium, which is the cause of the mismatch; human capital, which belongs to labour factors and also has knowledge attributes, therefore has high mobility and is the most active factor player, which is most likely to cause mismatch problems in factor markets.

On the one hand, China's human capital quality structure gradient upgrade obstacles, the second gradient intermediate human capital redundancy, and face upgrading difficulties to produce the middle and low level of human capital congestion, the third gradient high level human capital scarcity, high level human capital gradient critical effect caused the quality structure gradient upgrade barriers. On the other hand, the monopolistic nature of the government sector attracts a large number of third-tier high-level human capital to government-regulated sectors and purely financially funded institutions, and the shortage of high-level human capital in technology-intensive industries such as scientific research, information transmission, software and information technology services, and computer, communications and other electronic equipment manufacturing, has increased, resulting in a mismatch of human capital industries and a downgrading of the gradient, thus hindering innovation development.

The innovation-driven development strategy is ultimately a talent-driven strategy and should actively nurture innovative talents and encourage high-level talents to engage in research and innovation. Accordingly, we should encourage independent innovation and increase investment in education, shift from the introduction of appropriate technologies to independent innovation, gradually raise the level of independent R&D and innovation in China, and give full play to the incentive effect of the appropriate skills income gap on human capital investment. On the basis of a dynamic match between human capital accumulation and innovation level upgrading, the existing pattern and technological dependence in the current international division of labour should be changed, and the global value chain should be climbed to the top. Increase investment in basic education and vocational skills training, promote the quality improvement and organic integration of general and specialized human capital, improve the adaptability of human capital to the new technological environment, guide it to update and enrich its skills and knowledge in a timely manner in the context of

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

technological change and economic transformation, and promote the dynamic shift from the quantity of human capital to the comparative advantage of the quality structure of human capital.

In addition, market orientation should be strengthened and administrative monopoly gains should be eliminated. Enhance the relationship between monetary wages and the level of human capital and job performance, interrupt the chain of related interests attached to government functionaries, increase the degree of marketisation of human capital pricing, eliminate the hidden differences in relative remuneration caused by the institutional segmentation of the labour market, and form the correct price signals for human capital allocation. Promote the equal use of production factors by all types of ownership, open, fair and equitable participation in market competition, ensure that the returns from innovation are synchronised with the returns from human capital, and provide a stable market environment, fair financing standards and supportive macro policies for human capital innovation activities.

4.2 Endogeneity Test

Based on possible omitted variables, endogeneity and intercorrelation, the lagged second period of the human capital industry allocation gradient and the quality structure gradient were used as instrumental variables, and the 2SLS model and GMM model were used to exclude possible reverse causality, heteroskedasticity or autocorrelation in the model, and the results of the endogeneity test are shown in Table III.

TABLE III. Endogeneity test results

Variable Code	**(1)**	**(2)**	**(3)**
	Ln _ patent	*Ln _ patent*	*Ln _ patent*
H _ allo	-0.0374825***	-0.0626301***	
	(0.0108444)	(0.0188973)	
H _ qual	0.5818474***		.7525137***
	(0.1564315)		(.2752854)
Ln _ RD	0.9538797***	0.6981968***	.552546***
	(0.0455367)	(0.0678299)	(.0621933)
RD _ ratio	-0.093114***	-0.0508839	-.0658782
	(0.0334346)	(0.0522524)	(.0613839)
Ln _ paper	0.7322872***	0.9402412***	.9158091***
	(0.0484097)	(0.073906)	(.0738265)
Ln _ literature	-0.1914316***	-0.1399798**	-.1901052***
	(0.0427953)	(0.0609924)	(.0617298)
Ln _ enterprise	-0.5054205***	-0.3887908***	-.1751062***

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

	(0.0430195)	(0.0634474)	(.0566302)
_cons	-0.5387926**	-1.571319***	-2.105883***

Note. *, **, *** indicates significant at the 10%, 5% and 1% levels respectively and values in brackets are standard errors

According to the analysis results in Table III (1), (2) and (3), it can be seen that the effects of the human capital industry allocation gradient and the quality structure gradient on innovation development do not suffer from reverse causality and autocorrelation, which are both significant at the 1% level, and also further validate the robustness of the benchmark regression results.

4.3 Analysis of Regression Results for Threshold Effects

The results are shown in Table IV. It can be seen that the human capital quality structure gradient itself is the threshold variable, and since it does not pass the triple threshold effect test, there is a double threshold, with the threshold value θ_1 being 0.0877 and θ_2 being 0.1393.

TABLE IV. Threshold effect test results

$r(H\_qual)$			Confidence Level		
	Threshold	**Fstat**	**10%**	**5%**	**1%**
Single	0.0877	21.06**	16.7320	19.8635	25.8394
Double	0.0877	21.06**	16.3799	20.1110	26.0911
	0.1393	15.85*	14.2407	16.5173	22.1844
Triple	0.0877	21.06**	15.8959	19.1665	27.3515
	0.1393	15.85*	13.5006	16.0049	22.1097
	0.2097	7.49	22.3331	26.4460	35.3830

Note. *, **, *** denote significant at the 10%, 5% and 1% levels respectively, threshold values were determined using Bootstrap sampling 1000 times

The results of the threshold effect regression test are shown in Table V. When the gradient of human capital quality structure is less than 0.0877, human capital plays a large hindering effect on innovation development, with an impact coefficient of -5.12 and significant at the 1% level; when the gradient of human capital structure is between 0.0877 and 0.1393, the hindering effect of human capital on innovation development decreases significantly, with an impact coefficient of - When the structural gradient of human capital quality is greater than 0.1393, the impact coefficient is 0.73 and is significant at the 1% level. The regression results show that hypothesis 3 is valid, the human capital quality structure gradient reaches a certain threshold but hinders the development of innovation, which indicates that the human capital quality structure gradient is too low, a large number of low-quality human capital is not conducive to

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

creating a good innovation environment, while continuously optimizing the talent structure and improving the quality of talent can mitigate its hindering effect, and through increasing efforts to cultivate high-level talent, to achieve the benign development of innovation.

TABLE V. Threshold regression test results

Variable Code	*H _ qual*		
Threshold Interval	$(r<\theta_1)$	$(\theta_1<r<\theta_2)$	$(r>\theta_2)$
Regression Results	-5.115057***	-0.8409413*	0.7335792***

Note. * , * * , * * * indicates significant at the 10%, 5% and 1% levels respectively and values in brackets are standard errors

Further analysis based on the results of the econometric test of hypothesis 3 shows that the impact of upgrading the gradient of human capital quality structure on innovation development is non-linear, and there is a threshold effect that the gradient of human capital quality structure reaches a certain threshold but hinders innovation development, which is mainly due to the following two reasons.

Firstly, the "erosion effect" and learning by doing. The "erosion effect" stems from the reduction in the potential number of effective units of labour due to technological progress, and the need for human capital to adapt to the new technological environment by learning by doing to continuously improve its own skills, leading to a stepwise upgrading of the quality structure of human capital, and based on the reverse impact of the new technological environment, the gradient of the quality structure of human capital The human capital quality gradient reaches a certain threshold and hinders the development of innovation.

Second, educational lag and gradient leap. However, there is a lag in education investment at this stage, i.e. the current level of education needs to be continued for a certain period of time in order to complete the corresponding years of schooling, so the “erosion effect” at this stage will stimulate dry schooling and increase education The “erosion effect” at the present stage will therefore stimulate learning by doing and increasing investment in education, which will lead to a structural gradient in the quality of human capital in the future, thus creating a sudden structural threshold effect on the impact of innovation development.

4.4 Analysis of Double Difference Results

Firstly, a mediating effects test was conducted to examine whether the impact of the industry allocation gradient of human capital on innovation development was affected by exogenous environmental factors, the results of which are shown in Table VI (1), (2) and (3).

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

TABLE VI. Intermediation effects and double difference test results

Variable Code	(1)	(2)	(3)	(4)
	Ln _ patent	*group*	*Ln _ patent*	*Ln _ patent*
H _ allo	-0.2629437***	-0.0280436***	-0.2145434***	
	(0.0283488)	(0.0047508)	(0.0285399)	
group			1.725892***	-0.2861205**
			(0.3106977)	(0.1246092)
Control Variables	YES	YES	YES	YES
_cons	7.576207***	0.1842679***	7.258181***	1.053828

Note. * , * * , * * * indicates significant at the 10%, 5% and 1% levels respectively and values in brackets are standard errors

where the coefficient λ_1 of the total effect equation (2.3) for the impact of the sectoral allocation gradient of human capital on innovation development is -0.2629437 and significant at the 1% level, and the mediating effect holds.The coefficient μ_1 of equation (2.4) is -0.0280436 and significant at the 1% level, indicating the effect of the human capital industry allocation gradient on the dummy grouping variable before and after the implementation of the Decision, and the coefficient π of equation (2.5) is 1.725892 and significant at the 1% level is the effect of the dummy grouping variable on innovation development after controlling for the effect of the human capital industry allocation gradient. Coefficient λ_1' of -0.2145434 and significant at the 1% level, being the direct effect of the industry allocation gradient of human capital on innovation development after controlling for the effect of dummy variables. $\mu_1\pi$ is of the same sign as λ_1', so there is a partial mediating effect, and the proportion of the mediating effect to the total effect is $\mu_1\pi / \lambda_1$, i.e. 18.41%. Accordingly, a double difference test can be conducted to further analyse whether the implementation of the Decision will accelerate the upgrading of the human capital sector allocation gradient and encourage innovation and development.

The results of the double difference are shown in Table VI(4) with a coefficient of -0.2861205 and significant at the 5% level for the dummy grouping variable $group_{it}$. It is clear that the Decision on the Establishment of Intellectual Property Courts in Beijing, Shanghai and Guangzhou, adopted in 2014, has had a large impact on the regions concerned. The Intellectual

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

Property Court is another specialized people's court established in China following the Military Court, the Railway Transport Court and the Maritime Court. Through the implementation of the Decision, the judicial protection of intellectual property rights can be further strengthened, the legitimate rights and interests of rights holders engaged in high-tech-oriented industries can be effectively protected in accordance with the law, and the gradient of human capital industry allocation in Beijing, Shanghai and Guangzhou can be effectively promoted. The validation of hypothesis 4 suggests that there is regional heterogeneity in the sectoral allocation of human capital to innovation development for a given level of human capital quality structure, which is the result of a combination of policy orientation and income disparity.

As the urbanisation process has long been government-led, the government regulates the direction and path of urbanisation through administrative means. The sectoral allocation of human capital is determined by labour market demand, and human capital chooses to allocate itself to the market sector, the monopoly sector or the functional government sector in order to maximise returns. When the policy orientation is inconsistent with the market orientation, government intervention distorts the relative sectoral pay structure, and the third-tier high-level human capital will be more concentrated in the monopoly sector and the government sector rather than in technology-intensive industries, leading to the problem of human capital sectoral mismatch problem, making it difficult to effectively promote innovative development.

In addition, the impact of natural endowments and ecological environments on urban innovation is reflected in both the attraction of high-level human capital to the third tier and the constraints on special manufacturing industries. The demand for quality of life of high-level talents drives them to choose cities with a more livable environment, such as the high latitude Northeast with its harsh climate and long winters, which is less attractive to high-level talents and not conducive to promoting local innovation development. On the other hand, the distribution of some high-end manufacturing industries is not only influenced by technology, but also constrained by the natural endowments of land, minerals and ecology in the region. For example, aerospace manufacturing industries require flatter and more open terrain conditions, and therefore occupy a larger distribution ratio in the western region, which promotes the gradient upgrading of human capital industry allocation and promotes innovation development in the region.

V. CONCLUSION

This paper studies the issue of the mechanism of the influence of human capital gradient upgrading on innovation development, divides human capital into industry allocation gradient and quality structure gradient, and sorts out the mechanism of the influence of human capital gradient upgrading on innovation development by analysing the blockage of innovation

Forest Chemicals Revew
www.forestchemicalsreview.com
ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

development, in an attempt to achieve diversified human capital industry allocation and scientific human capital quality structure, so as to promote innovation development more effectively.

First of all, the gradient of human capital quality structure effectively promotes innovation development, while the mismatch of human capital sectoral allocation hinders innovation development. The hypothesis is verified by the benchmark regression model, and the analysis shows that the hindrance of human capital mismatch to innovation development is mainly reflected in the mismatch between human capital level and job level. The mismatch between the level of human capital and the level of jobs is the main impediment to innovation development. The quality gradient of human capital in China is a major impediment to upgrading, and the government sector, by virtue of its monopoly nature, attracts a large amount of high-level human capital in the third gradient to government-regulated sectors and purely financially funded institutions.

Secondly, the impact of advanced human capital structure on innovation development is non-linear, and the hypothesis is verified by constructing a threshold regression model, i.e. there is a threshold effect where the gradient of human capital quality structure reaches a certain threshold but hinders innovation development, mainly based on the "erosion effect" and the reverse impact of dry schooling, educational lag and gradient leap.

Finally, by constructing a double difference model to test innovation development in the five years before and after the implementation of the Decision on the Establishment of Intellectual Property Courts in Beijing, Shanghai and Guangzhou, it further analyses the existence of regional heterogeneity in the sectoral allocation of human capital to innovation development for a given level of human capital quality structure, as a result of the combined effect of policy orientation and income disparity.

ACKNOWLEDGEMENTS

This research was supported by Social Sciences Project of Heilongjiang Province (17021, 18052, 19039, 21ZK036), Teacher Innovation Support Project of Harbin University of Commerce (XW0076).

REFERENCES

[1] Li PM. Innovative development of human resource development theory and practice in China from a new historical starting point (below). China Human Resource Development, 2021, 38(01): 2-3.
[2] Zhai SH, Zhang J. Historical human capital policies, modern human capital and urban innovation

ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

level. New Economy, 2020(08):69-75.

[3] Qi ZD, Lin J (2020) Audit of human capital management in innovation-driven enterprises. Economy and Management, 34(04):88-92

[4] Feng JR (2020) An empirical study on the impact of human capital on regional innovation efficiency. Technology Economics, 39(12):123-130.

[5] Pei KB (2021) R&D human capital allocation and technological innovation - a heterogeneous education level perspective. Science and Technology Progress and Countermeasures, 38(14):11-20.

[6] Gu JJ, Zhao YL(2021) How can China get out of the dilemma of science and technology innovation? --A new perspective based on the synergistic development of science and technology innovation and human capital. Science Research, 39(01):129-138.

[7] Li J, Nan Y, Liu XH (2017) China's economic growth stabilization dilemma: human capital mismatch and its solution. Economic Research, 52(03):18-31.

[8] Xu CJ, Huang TM. Worker compensation, heterogeneous human capital and economic growth. Guizhou Social Science, 2019(02):135-142.

[9] Squicciarini M P, Voigtländer N. Human capital and industrialization: Evidence from the age of enlightenment. The Quarterly Journal of Economics, 2015, 130(4): 1825-1883.

[10] Li JQ, Zhao XL, Zhang Reclamation Bin. Education expansion, human capital and corporate innovation. China Economic Issues, 2019(03):81-94.

[11] Fonseca T, de Faria P, Lima F. (2019) Human capital and innovation: the importance of the optimal organizational task structure. Research policy, 48(3): 616-627.

[12] Kianto A, Sáenz J, Aramburu N (2017) Knowledge-based human resource management practices, intellectual capital and innovation. Journal of Business Research, 81: 11-20.

[13] Sun X, Li H, Ghosal V. Firm-level human capital and innovation: Evidence from China. China Economic Review, 2020, 59: 101388.

[14] Hsu D H, Ziedonis R H (2013) Resources as dual sources of advantage: Implications for valuing entrepreneurial-firm patents. Strategic Management Journal, 34(7): 761-781.

[15] Zhang ZD, Wu D (2019) Advanced human capital structure and industrial innovation efficiency enhancement - an empirical analysis based on the Yangtze River Economic Belt. Contemporary Economic Management, 41(09):67-74.

[16] Yuan FH, Zhang P, Lu MT. The structure of human capital in the long-term economic growth process--Also on the upgrading of human capital gradient in China. Economic Dynamics, 2015(05):11-21.

[17] Jiang FX, Wang ZJ, Bai JH. The double effect of environmental regulation on technological innovation--an empirical study based on dynamic panel data of Jiangsu manufacturing industry. China Industrial Economics, 2013(07):44-55.

[18] Wang J (2020) Social integration of foreign populations and urban innovation in China. Journal of Nanjing Audit University, 17(04):92-101.

[19] Wang JM, Yang L. Innovation factors, allocation efficiency and innovation performance in the Yangtze River Delta. Shanghai Economic Research, 2020(01):75-85.

[20] Zhang N, Fan HM, Mu HZ. The economic growth effect of gradient upgrading of human capital. Population and Economy, 2020(02):87-101.

[21] Ji WW, Lai DS. Human capital allocation and innovation performance in China. Economic

ISSN: 1520-0191
July-August 2021 Page No. 1451-1468
Article History: Received: 12 May 2021 Revised: 25 June 2021 Accepted: 22 July 2021 Publication: 31 August 2021

Dynamics, 2018(11):19-31.

[22] Feng FP, Wei QH. (2020) Industrial policy, technology human resource allocation and corporate innovation risk. Investment Research, 39(05):142-157.

[23] Li HQ, Mao SP (2020) The impact of human resources on innovation efficiency in Chinese agricultural research institutes--and the importance of choosing a science and technology innovation model. Science and Technology Management Research, 40(12):96-103.

[24] Sun B, Liu SS, Ge CM, Peng BY (2021) Research on the impact of talent mobility network on the speed of innovation of enterprises. Science, 39(06):1120-1129.

[25] Gao Q, He F, Lv Q (2020) Research on the efficiency of university science and technology innovation in the context of industry-university-research collaborative innovation--an empirical analysis based on panel data of key universities in China. Research and Development Management, 32(05):175-186.

[26] Lu T, Wang XZ (2020) Research on the human capital threshold effect of science and technology finance on regional green innovation efficiency enhancement. Journal of Social Sciences of Hunan Normal University, 49(05):71-81.

[27] Peng X, Jiang CH (2011) Industrial agglomeration, knowledge spillover and regional innovation - an empirical test based on Chinese industrial sectors. Journal of Economics (Quarterly), 10(03): 913-934.

[28] Bruce, E, Hansen (1999) Threshold effects in non-dynamic panels: Estimation, testing, and inference. Journal of Econometrics.

[29] Report of the Legal Committee of the National People's Congress on the Results of Deliberations on the Decision on the Establishment of Intellectual Property Courts in Beijing, Shanghai and Guangzhou (Draft) - 31 August 2014 at the Tenth Session of the Standing Committee of the Twelfth National People's Congress . Bulletin of the Standing Committee of the National People's Congress of the People's Republic of China, 2014(05):618-619.

[30] Zhao T, Zhang Z, Liang SK (2020) Digital economy, entrepreneurial activity and high-quality development - empirical evidence from Chinese cities. Management World, 36(10):65-76.

[31] Lu T, Dang Y (2014) Corporate governance and technological innovation: A comparison by industry. Economic Research, 49(06):115-128.

[32] Yang LG, Gong SH, Wang P, Chao ZS. Human capital, technological progress and manufacturing upgrading. China Soft Science, 2018(01):138-148.