Research on the Influencing Factors of the Flow of Scientific and Technological Talents in Shaanxi − Based on Granger Causality Test and Gray Correlation Analysis

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Abstract

This paper selects the relevant data of Shaanxi Province from 2010 to 2020, and uses SPSS and Eviews measurement software to explore the main factors affecting the flow of scientific and technological talents by Granger causality test and gray correlation analysis. Gray correlation analysis shows that the proportion of the second and third industries in GDP is the fundamental economic factor affecting the flow of scientific and technological talents. The Granger causality test results show that the impact of the economic development level of the tertiary industry and regional GDP on the stock of scientific and technological talents has a three-year lag period, and the results of the two methods confirm each other in terms of economic factors. The level of R&D investment is a political factor affecting the flow of scientific and technological talents. The results of science and technology transformation are cultural factors and green environment is social factors.

Keywords-*Economic and social development level; Science and technology talent flow; Granger causality test; Grey correlation analysis*

1. INTRODUCTION

The reasonable and orderly flow of scientific and technological talents is related to the realization of the strategic goal of China 's innovative country and the core of talent strategy. In December 2019, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council jointly issued the ' Opinions on Promoting the Reform of the System and Mechanism of Social Mobility of Labor and Talents ', which clearly stated that a prerequisite for promoting sustained and healthy economic development and social harmony and progress is ' rational, fair, smooth and orderly social mobility of talents '. In September 2021, at the Central Talent Work Conference, General Secretary Xi proposed that ' comprehensive national strength competition is talent competition, scientific and technological talent is an important indicator of a country 's comprehensive national strength.

Shaanxi Province, as a big talent province, has a slow economic and social development. By 2020, the average education years of the population aged 15 and above in Shaanxi Province were 10.26 years, ranking 7th in the country, and the regional GDP was 261.81 billion yuan, ranking 14. Compared with the results of the seventh national census and the GDP ranking of provinces and cities in 2020, it is found that the education level of the region is not proportional to the level of economic development. The key reason is that science and technology talents in Shaanxi Province gathered and did not form a benign and orderly flow. Therefore, exploring the factors affecting the flow of scientific and technological talents, especially the relationship between economic and social development and scientific and technological talents, is not only a supplement to the theory of human capital, but also a realistic demand for the implementation of innovation-driven development, which has reference significance for promoting economic and social development in other regions.

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2. Theoretical Research and Current Situation

2.1. Theoretical research

Scientific and technological talents refer to those with higher education background, rich professional knowledge and skills [1], good innovative thinking and creative ability, or those without higher education background but with scientific and technological expertise who are engaged in scientific and technological undertakings [2-3]and can contribute to the progress and development of science and technology, economy and society[4]. The flow of scientific and technological talents is the process of continuous development and refinement of social division of labor, and is the inevitable phenomenon of the active flow and transformation of various majors, occupations, industries, regions and scientific and technological forces. Good and orderly flow of scientific and technological talents is conducive to improving the level of technological innovation in the region[5-6] and further enhancing regional economic benefits[7]. Disordered scientific and technological talent flow will have a negative impact[8] on regional economic development, will expand the economic gap between regions, resulting in scientific and technological talent resources differentiation[9].

2.2. Current Situation of Science and Technology Talent Flow in Shaanxi Province

In recent ten years, the number of scientific and technological talents in Shaanxi Province increased from 98710 to 167628, showing an upward trend. According to the distribution and mobility of institutions, the number of scientific and technological talents in colleges and universities is the largest, accounting for about 30%, followed by scientific research institutions, accounting for about 20% ; according to the scale of enterprises, scientific and technological talents are mainly distributed and flowed to large enterprises above scale, accounting for about 59.88% ; by region, mainly distributed and flowed to Xi ' an, accounting for about 76%, 3.2 times the total number of talents in other regions of the province. Xi ’ an is the most densely populated area of Shaanxi universities and scientific research institutions, the base for the development of industrial enterprises of scale and above, and the gathering center of Shaanxi scientific and technological talents.

3. Data Sources and Research Methods

3.1. Data sources

The research data are mainly from the 'China Statistical Yearbook', 'China Statistical Yearbook of Science and Technology', 'China Statistical Yearbook of High-tech Industries', 'Shaanxi Statistical Yearbook' and the Statistical Bulletin on National Economic and Social Development of Shaanxi Province, 2010-2020, published by the National and Shaanxi Provincial Government Statistics Bureaus at all levels.

3.2. Research method

Firstly, the data were filtered, and the missing data in the statistical data were supplemented by the maximum likelihood estimation method in SPSS software to ensure the integrity of subsequent data calculation. Secondly, using Eviews software to test the Granger causality between the level of economic development and the stock of scientific and technological talents. Finally, the gray correlation analysis method is used to analyze the influence of economic, policy, cultural soft environment and social natural environment on the flow of talents, so as to quantify and sequence the relationship.

4. Relationship between Economic Development Level and Scientific and Technological Talent Stock

Through Eviews software for data single test, lag order judgment, Granger causality test and regression test, from the overall level of development and the main development indicators to measure the impact of scientific and technological talent stock and flow. In the analysis of the stock of scientific and technological personnel (Y) mainly with R&D personnel to carry out data statistics, the level of economic development in Shaanxi Province indicators GDP (X0), industrial added value (X1), the third industry added value (X2), high-tech industry operating income (X3), the whole society fixed asset investment (X4), total retail sales of social consumer goods (X5), urban per capita income (X6) and urban registered unemployment rate (X7) seven items.

4.1. Data stability test and lag order judgment

The ADF test method is used to test the unit root of data stability. The results show that the P values of the ADF test under the second-order difference of each index are all less than 0.05, indicating that there is no unit root in the data, that is, the overall data are stable. Through the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Hannan-Quinn Criterion (HQ) to determine the optimal lag period between variables, it is found that the lag period of each index is 3 years. Test results are shown in table 1.

TABLE 1. Judgement table of lag order

Index	AIC	BIC	HQ
X0 (people)	-71.07048*	-71.17866*	-72.40757*
X1 (billion yuan)	-46.08670*	-46.19488*	-47.42378*

X2 (billion yuan)	-63.90881*	-64.01699*	-65.24589*
X3 (billion yuan)	-61.50996*	-61.61814*	-62.84704*
X4 (billion yuan)	-72.65687*	-72.76505*	-73.99395*
X5 (billion yuan)	-68.32944*	-68.43762*	-69.66652*
X6 (yuan)	-60.32925*	-60.43743*	-61.66633*
X7 (%)	-85.26996*	-85.37814*	-86.60705*

4.2. Granger causality test

H1: Changes in GDP (X0) and economic development indicators (X1-X7) in Shaanxi Province will not cause changes in the stock of scientific and technological talents (Y).

H2: The change of science and technology talent stock (Y) will not cause the change of GDP (X0) and economic development indicators (X1-X7) in Shaanxi Province.

TABLE 2. GRANGER CAUSALITY TEST RESULTS

Null Hypothesis	*F*-statistic	*P*	Conclusion
H1a X0 does not Granger Cause Y	0.78025	0.0388	Reject
H2a Y does not Granger Cause X0	11.5795	0.5335	Accept
H1b X1 does not Granger Cause Y	1.44745	0.3631	Accept
H2b Y does not Granger Cause X1	0.60987	0.5995	Accept
H1c X2 does not Granger Cause Y	12.7837	0.0340	Reject
H2c Y does not Granger Cause X2	0.50925	0.6450	Accept
H1d X3 does not Granger Cause Y	0.61621	0.5968	Accept
H2d Y does not Granger Cause X3	8.07460	0.0620	Accept
H1e X4 does not Granger Cause Y	1.72413	0.3173	Accept
H2e Y does not Granger Cause X4	7.65690	0.0663	Accept
H1f X5 does not Granger Cause Y	1.88106	0.2955	Accept
H2f Y does not Granger Cause X5	1.57262	0.3411	Accept
H1g X6 does not Granger Cause Y	1.68672	0.3229	Accept
H2g Y does not Granger Cause X6	1.25603	0.4015	Accept
H1h X7 does not Granger Cause Y	2.7308	0.2111	Accept
H2h Y does not Granger Cause X7	4.17951	0.1357	Accept

H1 and H2 test results table 2 shows that the *P* values of H1a and H1c are less than 0.05, then the hypothesis is not valid, indicating that GDP and the added value of tertiary industry in Shaanxi Province significantly affect the stock change of scientific and technological talents.

4.3. Model Setting and Parameter Estimation

By comparing the fitting degree between linear and nonlinear competition models, it is found that the fitting degree of linear function model is 0.875 and 0.820 respectively, and the highest fitting degree of nonlinear function model is logarithmic function model, which is 0.896 and 0.873 respectively. So this study uses logarithmic function model:

$$Y_t = \beta_0 + \beta_t \ln X_t + \mu_t \quad (1)$$

TABLE 3. REGRESSION RESULTS OF LOGARITHMIC FUNCTION MODEL

Variable	Coefficient	Std.Error	*T* Statistic	*Prob.*
C	-542992.8	81561.05	-6.657500	0.0002
LOG(GDP)	69231.93	8354.641	8.286644	0.0000
R-squared	0.895655	Meandependentvar		132597.4
AdjustedR-squared	0.882611	S.D.dependentvar		21557.33
S.E.ofregress	7385.97	Akaikeinfocrit		20.829

ion	6	erion		41
Sumsquared resid	4.36E+08	Schwarzcriterion		20.88993
Loglikelihood	-102.1471	Hannan-Quinncriter.		20.76302
F-statistic	68.66847	Durbin-Watsonstat		2.531969
Prob(F-statistic)	0.000034			
C	-325934.7	61850.40	-5.26973	0.0008
LOG(X2)	52024.44	7011.377	7.420003	0.0001
R-squared	0.873130	Meandependentvar		132597.4
AdjustedR-squared	0.857271	S.D.dependentvar		21557.33
S.E.ofregression	8144.259	Akaikeinfocriterion		21.02487
Sumsquared resid	5.31E+08	Schwarzcriterion		21.08539
Loglikelihood	-103.1244	Hannan-Quinncriter.		20.95848
F-statistic	55.05644	Durbin-Watsonstat		2.049731
Prob(F-statistic)	0.000075			

According to the ordinary least squares method, the regression equation is :

$$Y = -542992.8 + 69231.93 \ln x_0 \quad (2)$$

$$Y = -325934.7 + 52024.44 \ln x_2 \quad (3)$$

Table 3 results showed that the R2 are 0.895655 and 0.873130, the adjusted R2 are 0.882611 and 0.857271, The coefficient of determination and the modified coefficient of determination are relatively high, indicating that the model has good fitting effect on samples. and the corresponding P values were 0.000034 and 0.000075, It shows that GDP and the added value of tertiary industry in Shaanxi Province have a significant impact on the stock of scientific and technological talents.

The results of model (2) show that the stock of scientific and technological talents will increase 6923.93 people per 1% GDP growth in Shaanxi Province, and the number of scientific and technological talents will increase with the growth of GDP, that is, economic development will promote the flow of scientific and technological talents.

The results of model (3) show that every 1% increase in the tertiary industry in Shaanxi Province, the stock of scientific and technological talents will increase by 52024.44 people. The development level of the tertiary industry will directly determine the degree of industrial structure optimization and the speed of economic development in the region.

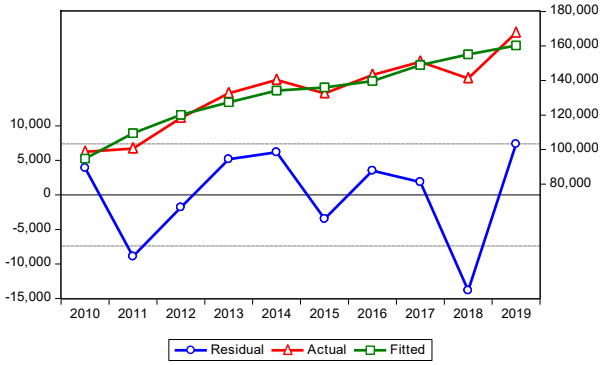

Figure 1. Residual, Actual and Fitting Values of Science and Technology Talent Stock and GDP

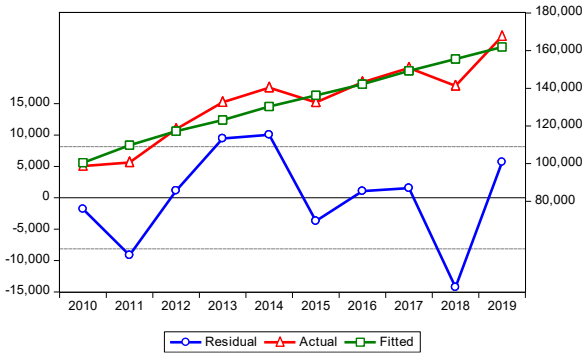

Figure 2. Residual, Actual and Fitting Values of Value Added of Tertiary Industry

Fig. 1 and Fig. 2 show that although the residuals of the model established in this study are random fluctuations, most of the residuals are located in the confidence interval, and the fitting degree is $\geqslant$0.85. The graph fitting effect is good, which further verifies the above results.

5. Influence of Economic and Social Development Level on the Flow of Scientific and Technological Talents

In this part, the gray correlation method is used to quantify and sort out the main dynamic factors affecting the flow of scientific and technological talents in Shaanxi Province. Gray correlation analysis is based on the similarity or difference of curve development trend between reference sequence and comparison sequence, that is, gray correlation degree', to determine the correlation between variables.

5.1. Establishing Index System of Gray Correlation Analysis

In gray correlation analysis, the reference sequence should be determined first, and then the comparison sequence should be determined. In this study, the flow rate of scientific and technological talents in Shaanxi Province is selected as the dependent variable, denoted as X_0. A total of 15 sub-factors are selected as independent variables from four aspects of economy, policy, cultural soft environment and social natural and hard environment, denoted as X_i (i = 1... 15), as shown in Table 4.

TABLE 4. REFERENCE DATA LIST AND COMPARISON DATA LIST

Reference sequence	Growth rate of scientific and technological personnel	X_0 Flow rate of scientific and technological talents (%)
Comparison sequence	economic factors	X1 GDP (billion yuan)
		X2 Per capita GDP (yuan)
		X3 value added (billion yuan)
		X4 Operating income of high-tech industry (billion yuan)
		X5 Proportion of secondary industry to GDP (%)
		X6 Proportion of tertiary industry to GDP (%)
	political factors	X7 Regional fiscal expenditure on science and technology (billion yuan)
		X8 The proportion of R & D expenditure in GDP (%)
		X9 Technology market turnover (billion yuan)
	cultural factors	X10 Number of scientific and technological institutions (PCS)
		X11 Number of college graduates (million people)
		X12 Number of books published (million volumes)
	social factors	X13 Urban per capita park green space area (m2)
		X14 green coverage rate of built district (%)
		X15 Number of visitors to Shaanxi(million person-time)

5.2. Calculation of gray correlation coefficient

$$\xi_i(k) = \frac{\min_i \min_k |X_0(k) - X_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \rho \max_i \max_k |x_0(k) - x_i(k)|} \quad (4)$$

Where the$\min_i \min_k |X_0(k) - X_i(k)|$ is the minimum absolute difference between X_0 and X_i, $\max_i \max_k |x_0(k) - x_i(k)|$ is the maximum absolute difference between X_0 and X_i. ρ is the correlation coefficient, which is introduced to reduce the influence of extreme value on the calculation. The value range is (0,1), and the general value is 0.5.

The grey correlation coefficient was calculated after dimensionless processing of the collected data. The calculation formula is shown in Equation 6, and the results are shown in Table 5.The correlation coefficient is the correlation value of each factor and the reference sequence. The closer to 1, the better the correlation.

TABLE 5. RESULTS OF CORRELATION COEFFICIENT

Index	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
X1	1	0.854	0.878	0.846	0.813	0.775	0.805	0.773	0.726	0.769

X2	1	0.855	0.88	0.847	0.816	0.78	0.808	0.78	0.73	0.78
X3	1	0.851	0.87	0.84	0.81	0.786	0.829	0.796	0.746	0.81
X4	1	0.863	0.879	0.847	0.8	0.743	0.732	0.698	0.663	0.682
X5	1	0.877	0.926	0.911	0.893	0.86	0.912	0.901	0.858	0.951
X6	1	0.885	0.936	0.915	0.892	0.841	0.882	0.873	0.832	0.902
X7	1	0.864	0.885	0.856	0.812	0.737	0.757	0.698	0.653	0.748
X8	1	0.888	0.941	0.916	0.899	0.852	0.9	0.895	0.848	0.927
X9	1	0.772	0.713	0.587	0.532	0.488	0.476	0.439	0.381	0.333
X10	1	0.904	0.919	0.884	0.86	0.822	0.852	0.823	0.802	0.85
X11	1	0.869	0.915	0.904	0.873	0.825	0.86	0.859	0.818	0.903
X12	1	0.899	0.932	0.916	0.899	0.849	0.904	0.898	0.841	0.911
X13	1	0.872	0.92	0.901	0.873	0.835	0.883	0.871	0.84	0.922
X14	1	0.879	0.924	0.907	0.886	0.847	0.895	0.887	0.849	0.93
X15	1	0.851	0.861	0.811	0.766	0.709	0.708	0.668	0.603	0.613

5.3. Correlation Degree Calculation and Ranking

The correlation coefficient only represents the correlation degree between the data at each time. Since there are many data of the correlation coefficient, it is not easy to compare. Therefore, the method of calculating the average value is generally used to centrally process and sort information. The expression of correlation degree is as follows.

$$R_k = \beta_0 \frac{1}{m} \sum_{i=1}^{m} \xi\left(X_0(t), X_i(t)\right) \qquad (5)$$

The results of table 6 show that the top five evaluation items affecting the correlation degree of scientific and technological talent flow rate in Shaanxi Province are the proportion of secondary industry in GDP, the proportion of R&D expenditure in GDP, the amount of book publication, the coverage rate of built-up area greening and the proportion of tertiary industry in GDP.

TABLE 6. RANK OF RELATIONAL DEGREE

Index	Degree of Association	Serial Number
X1	0.824	11
X2	0.828	10
X3	0.834	9
X4	0.791	13
X5	0.909	1
X6	0.896	12
X7	0.801	12
X8	0.907	2
X9	0.572	15
X10	0.872	8
X11	0.883	7
X12	0.905	3
X13	0.892	6
X14	0.900	4
X15	0.759	14

The first evaluation is the proportion of secondary industry to GDP, and the fifth is the proportion of tertiary industry to GDP. The proportion of the second and tertiary industries in GDP represents the scale and current situation of regional economic development, indicating that the level of regional economic development is an important factor affecting the flow of scientific and technological talents. The second place is the level of R&D investment. Most scientific and technological talents flow to regions with high R&D investment, indicating that the level of investment in scientific and technological innovation significantly affects the flow of scientific and technological talents. The third is the volume of books published. The results of scientific and technological achievements transformation represent the strength of scientific and technological innovation in a region. Higher scientific and technological innovation strength is the professional pursuit of scientific and technological talents. Regions with strong scientific and technological strength and good scientific research environment are more attractive to scientific and technological talents. The fourth environmental greening facilities. Compared with urban public facilities, scientific and technological talents pay more attention to the influence of social factors such as the level of living facilities and living environment closely related to their own lives.

6. CONCLUSION

It is found that the flow of scientific and technological talents is not determined or mainly determined by a certain unilateral relevant factor, but by four factors, namely, economic, political, cultural and social natural and hard environment, which work together. Among them, economic factor is the primary factor. Among the top five factors affecting the flow rate of scientific and technological talents in Shaanxi Province, economic factors account for two, and political, cultural and social natural factors account for one.

Among the economic factors, the gray correlation analysis shows that the proportion of the secondary and tertiary industries in GDP is the fundamental economic factor affecting the flow of scientific and technological talents. At this stage, the economic development level of the secondary industry is the main influencing factor, followed by the economic development level of the tertiary industry. Granger causality test found that at least three years later, the level of economic development of the tertiary industry and GDP will become the main economic factors affecting the stock of talents in Shaanxi. The results of the two methods are verified in time.

Among the political factors, the proportion of R&D expenditure in GDP is an important factor affecting the flow of scientific and technological talents. The level of R&D expenditure is the basic condition of regional scientific and technological innovation and the driving force of innovation. Therefore, balancing the R&D investment across regions is the key to revitalizing talents.

Among the cultural factors, the achievements of scientific and technological transformation are the overall performance of scientific and technological strength in the region and the main reason affecting the flow of scientific and technological talents.

Among social factors, the greening coverage rate of built-up areas is closely related to the living environment of scientific and technological talents, and it is the key factor affecting the flow of scientific and technological talents in Shaanxi.

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