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Research on the measurement of contribution value of scientific and technological talents in China's mining industry——Innovative application based on "Cobb Douglas production function method"

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Research on the measurement of contribution value of scientific and technological talents in China's mining industry——Innovative application based on "Cobb Douglas production function method"

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Abstract. This paper aims to determine the contribution value of scientific and technological talents from Mining to national economic development, with data collecting on the correlations between the national Mining and the national economic development from 2005 to 2019, comprising the added value, the capital formation and the total wages and growth rate of the Mining. Through the Cobb-Douglas production function method, the contribution index of Mining talents was confirmed. Combining this index with high-tech talents, the contribution value of Mining science and technology talents was calculated and determined by using big date and informatization method. The results show that in 2005, the contribution value of scientific and technological talents in China's mining industry in enterprise scientific and technological research and development was 2288.4 yuan / person year, which increased to 3821.1 yuan / person year in 2018, with an average annual increase of 4.01%, 16 years average 7011.1 yuan / person year. This value is much lower than the contribution of capital, and its output elasticity (index) is only 7.42% of capital. However, this is the result of the scientific and technological talents in the mining industry with the value of selfless dedication. It is the real motivation and purpose of the author to write this paper: appeal to the state, society and enterprises to increase the scientific and technological investment in the mining industry and constantly improve the conditions and treatment of scientific and technological talents in the mining industry.

1. Introduction

China's mining industry is composed of five industries: mining and washing of coal, extraction of petroleum and natural gas, mining and processing of ferrous metal ores, mining and processing of non-ferrous metal ores, mining and processing of non- metal ores. It is an extensive production unit in China. China's extensive production units mainly rely on capital investment and strong labor input, and their production and operation and the technical content of their products are insufficient. However, the Chinese government and the market continue to guide mining enterprises to increase investment in science and technology, especially to give full play to the role of scientific and technological talents. The writing motivation and purpose of this paper is to analyze how the role of scientific and technological talents in extensive units such as China's mining industry is played? At the same time, in the previous research process, the role of scientific and technological talents is often reflected by the index of "labor force", which can not truly reflect the contribution of scientific and technological talents.

So, this paper discusses the contribution of scientific and technological talents in China's mining industry to scientific and technological research and development from the perspective of value indicators.

2. Research on the Performance of Scientific and Technological Talents in Mining

On CNKI.cn, the research results on the contribution performance of scientific and technological talents in Mining mainly involves two aspects: research content and research methods.

The first point is to study the contribution performance of talents as well as research results of other scientific research performance. Through studying the level of scientific research, scientific innovation ability and the situation of the combination of production study and research in Mining in Henan Province, Ye Jing (2017) constructed the evaluation system of scientific and technological innovation performance, including scientific and technological talents, funds for scientific research projects, papers and monographs, cooperation and transformation of production, education and research and intellectual property rights [1]. With the applying of data of 2006-2016 Compilation of Science and Technology Statistics of China's mining industry and in reference to the 2015 scientific research efficiency level of Mining in 12 Provinces in the west of China, Fang Lijuan et al. (2018) managed to evaluate of the scientific research efficiency level of Mining in Ningxia Province. The measurements include: first, scientific research investment: Scientific researchers, research and development staffs; second, Patents for inventions and sales revenue of new products [2]. Taking Beijing Mining as an example, Yan Jian et al. (2016) designed measurements such as science and technology funds, investment on science and technology manpower, rewards for achievement, science and technology subjects, ownership and authorization of patents, licensing and transferring of patents, etc. The data of input and output of science and technology from 2004 to 2013 in 15 Mining in Beijing were analyzed through empirical analysis. The input and output constructure of Beijing has been deemed reasonable. Scientific and technology achievements is related to yearly total input, number of scientific and technological personnel and so on in Chinese [3].

The second point is to study the contribution performance of talents through the same evaluation method adopted by other research achievements. In addition to the clustering method adopted by above-mentioned Yan Jian, connecting the S&T innovation during the period of the Twelfth Five-Year, Wang Xiaomeng (2018) finished the research of her own performance (including talent contribution performance) in Chinese [4]. Through data 2011-2014 studying and the using of fixed-effect model, Meng Fanrong et al.(2017) compared the performance of scientific and technological innovation among enterprises, Mining and scientific research institutions, and it has been confirmed that the quantity of scientific and technological human resources of Mining and scientific research institutions had a major significant effect on scientific and technological innovation: the contribution from enterprises is mainly reflected on the competition with each other; The contribution from Mining is mainly embodied as the inclusiveness of other research contents in Chinese [5] . Wu Dandan et al. (2016) conducted empirical analysis on the performance of scientific and technological innovation in Mining by using nonlinear regression analysis based on the scale independent zone in Chinese. It is believed that the changes of regional GDP, input and output of scientific and technological innovation in Mining have significant non-linear effects on the performance of scientific and technological innovation in Mining in Chinese [6].

In their study, Varrichio et al. (2012) emphasise the role of synergy in future innovation, i.e. that the future trend in innovation management is to promote and improve performance through the coordination of linkages between research institutions, production sectors and government [7]. Sadegh Rast (2013) used a collaborative approach to assess the assignment of perceptual parameters in five types of Mining and research institutions in Malaysia to derive a preliminary framework for influencing performance across parameters [8].

Although the above research results are innovative in multiple aspects, there are still three deficiencies: firstly, the research only pays attention to data of researchers involved in this research, or "full-time equivalent" data, but ignores the value attribute of researchers; secondly, it did not integrate foreign research methods on this subject; thirdly, measurements were selected only from Mining in a limited number of provinces or regions, did not draw an overall picture. This paper aims to evaluate the contribution value of scientific and technological talents in Chinese Mining by studying all the relevant data of Chinese Mining through the "Cobb-Douglas production function method".

3. Confirmation of mining talent contribution and scientific research contribution value

3.1. The determination of contribution rate of mining talents

The scientific research talents in Mining are the talents in Mining. The contribution rate of mining talents is contribution from the human resource in Mining, and normally adopt the Douglas production function method.

Table 1. Application of "Cobb-Douglas Production Function Method" in China's Mining from 2004 to 2019[a].

year	Added value of Mining (100 million yuan)	Growth rate of added value of Mining	Capital formation rate in GDP under national expenditure method	Capital formation amount calculated by Mining (100 million yuan)	Total wages of Mining (100 million yuan)	Growth rate of total wages in Mining	Output elasticity of mining talents	Contribute index of mining talents
	1	2	3	4=2×3	5	6	7	8=7×6÷2
2004	7628.3		41.97%		821.2			
2005	10318.2	35.26%	40.27%	4155.5	1031.2	25.58%	0.0581	0.0421
2006	12082.9	17.10%	39.88%	4818.8	1259.6	22.14%	0.0581	0.0752
2007	13460.7	11.40%	40.42%	5441.0	1500.5	19.13%	0.0581	0.0975
2008	19629.4	45.83%	42.43%	8327.9	1847.3	23.11%	0.0581	0.0293
2009	20283.0	3.33%	45.47%	7605.2	2089.1	13.09%	0.0581	0.2284
2010	20936.6	3.22%	46.97%	9833.5	2458.8	17.70%	0.0581	0.3191
2011	27225.6	30.04%	47.03%	12804.0	3174.2	29.10%	0.0581	0.0563
2012	25093.0	-7.83%	46.19%	11589.4	3600.7	13.43%	0.0581	-0.0996
2013	25467.6	1.49%	46.14%	11749.7	3833.2	6.46%	0.0581	0.2513
2014	23417.1	-8.05%	45.61%	10681.1	3728.2	-2.74%	0.0581	0.0198
2015	19104.5	-18.42%	43.03%	8221.2	3318.2	-11.00%	0.0581	0.0347
2016	18514.8	-3.09%	42.66%	7897.5	3038.1	-8.44%	0.0581	0.1589
2017	21380.1	15.48%	43.17%	9230.2	3208.6	5.61%	0.0581	0.0211
2018	22592.3	5.67%	43.96%	9931.8	3413.4	6.38%	0.0581	0.0654
2019	23695.5	4.88%	43.07%	10205.2	3388.2	-0.74%	0.0581	-0.0088

Data source: China Statistical Yearbook from 2005 to 2021

The calculation formula is as follows:

$$GDP = A(t) L^{\alpha} K^{\beta} \mu$$

In the formula, *GDP* is the added value of Mining; *A(t)* is the comprehensive technical level, and *L* originally meant the number of labors invested (the unit is ten thousand person or person), which is often reflected with the total wages by later generations, but this paper uses the total wages in the Mining to reflect; *K* is the invested capital, including fixed capital and working capital, which is reflected with the "gross capital formation" in GDP calculated by expenditure method; α is the elasticity coefficient of labor output, β is the elasticity coefficient of capital output, and μ represents the influence of random interference. When $\mu = 1$, β is the complement of α.

When the above formula is applied, take the logarithm on both sides, and get:

$$LnGDP=LnA(t)+\alpha LnK+\beta LnL$$

See Table 1 for the application of "Cobb-Douglas Production Function Method" in China's Mining from 2004 to 2019.

3.1.1. Descriptive statistics. Using the data of "added value of mining industry", "calculated capital formation of mining industry" and "total wages of mining industry" in Table 1, operate spss26 0 statistical software for descriptive statistics, and the descriptive statistics table is shown in Table 2:

Table 2. Descriptive Statistics.

	N	minimum value	Maximum value	average value	standard deviation
Added value of Mining(100 million yuan)	15	10318.20	27225.60	20213.42	4961.28
Capital formation amount calculated by Mining(100 million yuan)	15	4155.50	12804.00	8940.63	2542.77
Total wages of Mining(100 million yuan)	15	1031.20	3833.20	2725.95	947.25
Number of valid cases (in columns)	15				

Results in Table 2 imply that the maximum value-added of China's mining industry is 272.560 billion yuan, the minimum value is 1031.82 billion yuan, and the average value is 2021.342 billion yuan. The calculated coefficient of variation is 24.5% (standard deviation 4961.28 ÷ average value 20213.42); The maximum value of capital formation calculated by China's mining industry is 1280.4 billion yuan, the minimum value is 415.55 billion yuan, and the average value is 894.063 billion yuan. The calculated coefficient of variation is 28.4% (standard deviation 2542.77 ÷ average value 894.63); The maximum value of total wages in China's mining industry is 383.320 billion yuan, the minimum value is 103.120 billion yuan, and the average value is 272.595 billion yuan. The calculated coefficient of variation is 34.7% (standard deviation 947.25 ÷ average value 2725.95). All indicators are in the normal range. The coefficients of variation of the three indicators are 24.5%, 28.4% and 34.7% respectively, which are in the range of "low variation" (10% - 40%), further indicating that the data dispersion is low and the reliability is strong.

3.1.2. Multicollinearity test. Take logarithms from the data of "added value of mining ", "capital formation amount calculated by mining" and "total wages of mining" in Table 1, and operate spss26 0 statistical software, conduct "multicollinearity" analysis, and obtain the multicollinearity test table, as shown in Table 3:

Table 3. Collinearity Diagnostics.

Dimension	Eigenvalue	Condition Index	Variable	Tolerance	VIF
1	2.932	1.000	Logarithm of added value		
2	0.056	7.260	Logarithm of capital formation	0.292	3.424
3	0.013	15.174	Logarithm of total wages	0.292	3.424

Results in Table 3 imply that the eigenvalue of each variable is greater than 0 and there is no collinearity; The condition index is less than the criterion 30, and there is no collinearity; VIF is less than the criterion 10, and there is no collinearity, so regression analysis can be carried out.

3.1.3. Regression analysis of Douglas production function model. Using the data in Table 1 to output Douglas production function by using EVIEWS least square method, see the results in Table 4:

Table 4. Output Douglas production function results table by using EVIEWS least square method [a].

Variable	Coefficient	Std. Error	t-Statistic
LnA(t)	2.3372	0.1871	12.4934***
LnK:	0.7830	0.0418	18.7362***
LnL:	0.0581	0.0327	1.7785*
R-squared		0.9972	
Adjusted R-squared		0.9934	
F-statistic		1054.8380	

[a] Note: *, * *, * * * mean significant correlation at the levels of 10%, 5% and 1% respectively (significance coefficients are 0.0000, 0.0000 and 0.1006)

The regression equation obtained from Table 2 is:

$$LnGDP = 2.3372+0.7830LnK+0.0581LnL$$

The coefficient of *LnL* in the regression equation 0.0581 is "the output elasticity of mining talents", that is, the elasticity coefficient of mining talents (the value reflected by the total wages) to the GDP of Mining is 0.0581, far less than the elasticity coefficient of capital to the mining industry of 0.7830. It can be seen that China's mining industry is still in the stage of capital led industrial development, and the contribution elasticity of scientific and technological personnel is only 5.81%.Fill 0.0581 in the rows of "output elasticity of mining talents" column in Table 1; the formula [9] for calculating the "contribution rate of mining talents" (accurately defined as the "contribution index of mining talents") according to the relevant data in Table 1 and Table 2 is as follows (fill the calculation results in Table 1):

Contribution Index of Mining Talents = Output Elasticity of Mining Talents × Growth Rate of Total Wages in Mining ÷ Growth Rate of Added Value in Mining.

3.2. Determination of the Value of contribution of scientific researchers in Mining

The original meaning of the production function model based on Cobb Douglas is that: the left side of the equation is the output, and the right side of the equation is the amount of capital and labor input (the amount of labor force [10]). when extending this formula, the author restores the "labor force quantity" and applies the "full-time equivalent of R & D personnel in mining industry", and believes that the meaning of the Scientific and technological talents Contribution Index is (take the actual data in 2018 as an example): the GDP of the Mining increases by 1%, and the contribution value of Scientific and technological talentss increases by 6.54%（0.0581×6.38%÷5.67%）. By applying this contribution index to the mining industry scientific researchers (quantity of scientific research and technical labor force is converted into full-time equivalent), he is able to calculate the value of contribution of scientific researchers in mining industry. The formula is as follows:

Value of contribution of scientific researchers in Mining = Scientific and technological talents Contribution Index × Full time equivalent of R & D personnel in mining industry.

The full-time equivalent of scientific and technological personnel and R & D personnel in China's mining industry from 2005 to 2019 is shown in Table 5:

Table 5. Full time equivalent of scientific and technological personnel and R & D personnel in China's mining industry from 2005 to 2019 unit: person year.

year	mining and washing of coal	extraction of petroleum and natural gas	mining and processing of ferrous metal ores	mining and processing of non-ferrous metal ores	mining and processing of non-metal ores	Total mining
2005	33473	18500	515	858	1011	54357
2006	38249	21140	588	980	1155	62112
2007	36051	26335	528	1842	1591	66347
2008	45955	26086	2108	2348	1710	78207
2009	50001	26105	1496	2194	2065	81861
2010	44636	26473	1413	2230	1949	76701
2011	50763.3	32371.8	1942.3	3147.5	3404.8	91629.7
2012	46917	24027.3	2270.3	3686.5	2791	79692.1
2013	53713	25487.2	2725.4	3955	3131	89011.6
2014	53027.7	28445.9	2840.9	3997.7	3864.6	92176.8
2015	43819	23040	3404	3833	2946	77042
2016	40193	24483	3296	4631	3314	75917
2017	41987	21463	2236	4420	3255	73361
2018	33477	13818	2425	5206	3495	58421
2019	33947	15512	3047	5689	4498	62693

Using the data in Table 1 and table 3, Calculate value of contribution of scientific researchers in Mining and fill in Table 6.

4. Research conclusions

The mining industry is China's basic production enterprises such as energy and steel, which plays a supporting role in the development of the national economy. As the mining industry involves the exploitation of mineral resources, it not only needs to invest a lot of assets to provide mining conditions, but also needs to invest a lot of manpower to mine resource products. These people have the spirit of hard work and are determined to work in difficult situations. They are labor heroes in the mining industry, especially scientific and technological workers. They give up the superior environment to work in mining enterprises, which is a lifetime of selfless dedication.from the perspective of "value" of economic management, this paper first uses the "Cobb Douglas production function method" to determine the contribution of mining workers to national GDP, and obtains the "output elasticity of mining talents" (coefficient) of 0.0581, which is only 7.42% (0.0581 ÷ 0.7830 × 100%) of the capital output elasticity of 0.7830), and then creatively apply the elasticity coefficient of talent output to the contribution of scientific and technological talents in the mining industry to find out the "contribution value of scientific and technological talents in the mining industry". Novel coronavirus pneumonia in China has increased its contribution value to 4.01% in the 2005-2020 years. The highest year in 16 years is 2010, which is 24475.3 yuan / person year, the lowest in 2019, which is 1540.0 yuan / person year (covid-19), 16 years average age of 7011.1 yuan per person.

Table 6. Measurement of value of contribution of Mining science and technology personnel in China's Mining 2005-2019.

year	Contribute index of mining talents 1	Full time equivalent of R & D personnel in mining industry (person year) 2	Value of contribution of scientific researchers in Mining (thousands/person) 3=1×2
2005	0.0421	54357.0	2288.4
2006	0.0752	62112.0	4670.8
2007	0.0975	66347.0	6468.8
2008	0.0293	78207.0	2291.5
2009	0.2284	81861.0	18697.1
2010	0.3191	76701.0	24475.3
2011	0.0563	91629.7	5158.8
2012	-0.0996	79692.1	2288.4[a]
2013	0.2513	89011.6	22368.6
2014	0.0198	92176.8	1825.1
2015	0.0347	77042.0	2673.4
2016	0.1589	75917.0	12063.2
2017	0.0211	73361.0	1547.9
2018	0.0654	58421.0	3820.7
2019	-0.0088	62693.0	1540.0[b]

[a] 2012 is the year when supply exceeds demand, product prices are reduced and downtime occurs in China's mining industry. The contribution value of scientific and technological talents in mining industry is not calculated according to the conventional formula, but determined according to the minimum value of 2288.4 in 2005 (the data calculated according to the formula -7940.9 is replaced by 2288.4).

[b] In 2019, China was covid-19, and the contribution of mining talents to science and technology was not calculated according to the regular formula, but was approximately determined as 1545.0 according to the lowest value of 1545.2 in 2017 (the data calculated according to the formula - 550.2 is replaced by 1545.0)

From 2005 to 2018, the contribution value of scientific researchers in Chinese Mining has been increasing with the changes of the contribution index of scientific researchers and mining talents, from 2288.4 yuan / person year in 2005 to 3821.1yuan / person year in 2018, with an average annual increase of 4.01%, From 2005 to 2019, 16 years average 7011.1 yuan / person year.

5. Novelty of the paper

There are three innovations in this paper: first, the index data of model application is innovative. In the past, only the "number of R & D personnel" or "full-time equivalent of R & D personnel" was used to study the role of scientific research talents, without considering the value contribution made by R & D personnel. By using the "Cobb Douglas production function method", we first measured the contribution of mining workers to GDP, and then combined with mining scientific and technological talents to determine the contribution value of mining scientific and technological talents, which has raised a research level compared with previous research; Second, the application of "Cobb Douglas production function method" is innovated. It not only calculates the output elasticity coefficient of scientific and technological talents (0.0581), but further deepens the application of this coefficient and creates two formulas: the contribution index of mining talents (output elasticity of mining talents × growth rate of total Wages in mining ÷ growth rate of added value in mining) and value of contribution of scientific researchers in mining(scientific and technological talents contribution index × full time equivalent of R & D personnel in mining industry),the application of "Cobb Douglas production function method" has been deepened and developed; The third is the comprehensiveness of the research samples. In the past, when Chinese scholars studied the contribution of scientific and technological talents in the mining industry, the selected index samples are often a province or a region or several mining enterprises. This paper takes China's five major mining departments as the whole of China's mining industry as the research samples. The research conclusions are comprehensive and improve the credibility of the paper.

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