Application of Least Square Approximation Algorithm in the Game Analysis and Data Prediction of the Core Competence Signal of Civil Engineering Employment

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Abstract: The least square approximation algorithm is often used to predict the data based on historical experience. In this paper, the method is applied to the research of "game analysis and data prediction of the core competence signal of civil engineering employment", which theoretically verifies the existence of "weak sequence" rational equilibrium in civil engineering employment by means of mathematical reasoning. In addition, the method is applied to the prediction of civil engineering major in one university in Heilongjiang Province from 2010 to 2019 as an example, and the empirical data of employment prove the real existence of the game signal. Finally, according to the method, the research predicts the related data of employment in 2020.

1 Introduction

National medium and long-term educational reform and development project summary (2010-2020) pointed out that ordinary colleges and universities should "focus on cultivating high-quality talents and top-notch innovative personnel with persistent faith, excellent moral character, rich knowledge, and strong ability", "support students to participate in scientific research, and strengthen practice teaching links", and "enhance education of employment and enterprising and employment guidance service". Accordingly, colleges and universities in Heilongjiang Province "is gradually transforming and upgrading talent cultivation concept by taking students as the main body and teachers as the leading, and putting efforts on fostering students' social responsibility, spirit of innovation and practical ability". Meanwhile, more attention is given to scientific research projects, an important indicator and main content to measure students' scientific research innovation level.

It is safe to say that students' participation in scientific research projects not only "adapts to objective needs of both the country and social development", but also "abide by the rules of higher education and talent growth". The development of this activity helps "deepen education and teaching reform, innovate education teaching methods, explore various cultivation methods, form a situation that a wealth of talents and top-notch innovative personnel coming out in succession", "cultivate students' scientific innovative level, tamp their major foundation, exercise their practical ability", and "strengthen students' employment competence, enhance their employment quality". In this paper, a game theory model "between students' scientific innovative level and

employment ability" is built, and empirical analysis is undertaken by using the data of scientific research projects and employment rate of students in civil engineering of one university in Heilongjiang Province in the past three years, with the expectation that it will bring some guidance effect on the real work^[1-3].

2 Establishment of the game model

2.1 Hypothesis of the model

(1)Client hypothesis: Firstly, two graduates with employment competence of H and L respectively, and $H > L$, and both meet "rational-economic person hypothesis", namely, they will actively choose the company who gives them the highest salary as their employer. Secondly, under the circumstances of market economy, two employers also meet "rational-economic person hypothesis", namely, they would like to hire the graduate with higher employment competence by giving the same lowest salary.

(2)Strategy hypothesis: First, scientific innovation level that the graduates formed in the school is e ; second, two employers give salary w_1 and w_2 after seeing e ; finally, each graduate chooses one salary (i.e. one employer).

(3)Payment hypothesis: The graduate with employment competence H pays a unit cost of e/H in the process of getting e , while the graduate with employment competence L pays a unit cost of e/L in this process. Therefore, profit models of graduates are $w_1 - e/H$ or $w_2 - e/H$ and $w_1 - e/L$ or $w_2 - e/L$

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2.2 Establishment of the model

(1) Graduate's strategy: The graduate of Type H is equipped with $e = e^*$ ($e^* > 0$), while the graduate of Type L possesses $e = 0$, if $w_1 > w_2$, then the graduates of both types all choose employer giving higher salary. If two employers give the same salary, namely $w_1 = w_2$, then the graduates will choose the first company.

The following Figure 1 is an "unfolding game theory model of imitating graduates who provide the two employers with their employment competence signal after receiving scientific innovative cultivation and training in university".

Note: Graduate's strategy and company's strategy in this Figure are compatible, namely, no graduate will choose any other scientific innovation level that is different from e^ and 0, and employers do not impose any restriction when choosing graduates with different employment competences.*

3 Analysis on game model

3.1 Graduate's action

(1) Type H graduate: If Type H graduate follows his own strategy and formed scientific innovative level e^* , then the profit he is going to get is $H - e^*/H$; if his formed scientific innovation level is e , then the profit is $L - e/H$. Therefore, to get equilibrium, we require $H - e^*/H \geq L$, namely, $e^* \leq H(H - L)$.

(2) Type L graduate: If Type L graduate follows his own strategy and formed scientific innovation level 0, then the profit he is going to receive is L ; if his formed scientific innovation level is e^* , then employer will believe his employment competence is H , and then his profit is $H - e^*/L$. Therefore, to get equilibrium, we require $H - e^*/L \leq L$, namely, $e^* \geq L(H - L)$.

3.2 Company's action

In conclusion, when and only when

$$L(H-L) \leq e^* \leq H(H-L)$$

4 Empirical study and data prediction

In order to further verify the real existence of this game theory model, this paper takes students in civil engineering of one university in Heilongjiang Province as study objects, extracts related data of "students

participating in scientific research" and "employment rate of overall graduates" of this department from 2010 to 2019, out of which "high-quality employment rate" and "Fortune 500 employment rate" are taken as a cut-in dot of study, and undertakes analysis and prediction respectively towards the following data in table 1 ,table 2 and figure 2.

4.1 Empirical study

4.1.1 Scientific researches participated by students in civil engineering of one university in the past four years

Table 1. Number of graduates participating in scientific researches and related employment data contrast from 2010 to 2019 Unit: person

Year	No. of students in scientific researches	No. of high-quality employment	Percentage
		No. of working in Fortune 500	
2010	67	28	41.79%
		16	23.88%
2011	136	59	43.38%
		32	23.53%
2012	128	56	43.75%
		32	25.00%
2013	131	59	45.04%
		34	25.95%
2014	125	56	44.80%
		35	28.00%
2015	129	60	46.51%
		37	28.68%
2016	72	34	46.58%
		21	29.17%
2017	96	53	55.21%
		36	37.50%
2018	117	83	70.94%
		49	41.88%
2019	112	81	72.32%
		57	50.89%

Note: Fortune 500 enterprises list is based on the data published by Fortune China, while high-quality employment includes employment in China Top 500, Heilongjiang Top 100 and enrollment as a postgraduate, soldier, civil servant or worker in public institutions.

4.1.2 Related employment data of students in civil engineering of one university in the past four years

Table 2. Graduate's overall employment and related employment data contrast from 2010 to 2019 Unit: person

Year	No. of graduates	No. of employment	Employment rate	No. of high-quality employment	Percentage
				No. of working in Fortune 500	
2010	475	455	95.79%	152	32.00%
				72	15.16%
2011	637	618	97.02%	217	34.07%
				115	18.05%
2012	602	576	95.68%	199	33.06%
				128	21.26%
2013	605	570	94.21%	203	33.55%
				124	20.00%
2014	598	572	95.65%	217	36.29%
				103	17.22%
2015	689	637	92.45%	237	34.40%
				113	16.40%
2016	632	601	95.09%	207	32.75%
				81	12.82%
2017	475	455	95.79%	167	35.16%
				43	9.05%
2018	637	618	97.02%	323	50.71%
				186	29.20%
2019	602	576	95.68%	309	51.33%
				168	27.91%

4.1.3 Data contrast and analysis

Fig. 2. Comparison of employment quality between two types of students

(1)Data in Table 1 and Table 2 indicate that from 2010 to 2019, high-quality employment rate of students in civil engineering of one university in Heilongjiang Province, whether the employment rate of graduates in scientific research or that of overall graduates, this index has been increasing year by year on the whole; percentage and growth scale of "high-quality employment rate of students participating in scientific

research" are much higher than current corresponding indexes. Data contrast is shown in Figure 2.

(2)When analyzing graduates' "Fortune 500 employment rate", we find out that this index from 2013 to 2017 decreased compared with that in the previous year. Exterior elements that influence employment caused the slide of this index include the downturn of domestic real estate market, the shrunk of construction engineering market, the slowdown of infrastructure investment, etc. However, "Fortune 500 employment rate" of students taking part in scientific research of those years still kept strong growth. Data contrast is shown in Figure 2.

4.2 Data prediction

Mathematical algorithm of "Least Squares Approximations" $y = a + bx$, out of which

$$a = \frac{\sum y_i - b(\sum x_i)}{n}, \quad b = \frac{(\sum x_i)(\sum y_i) - n(\sum x_i y_i)}{(\sum x_i)^2 - n(\sum x_i^2)}$$
 is

used to predict two data of "overall high-quality employment rate" and "high-quality employment rate of students participating in scientific research" of students in civil engineering major of one university in Heilongjiang Province in 2020. Details are as followed in Table 3 and Table 4.

4.2.1 Prediction on high-quality employment rate of graduates participating in scientific researches in 2020

Table 3. Calculation of related data of students participating in scientific researches from 2010 to 2019 Unit: percentage

x_i	y_i	x_i^2	$x_i y_i$
1	41.79%	1	41.79%
2	43.38%	4	86.76%
3	43.75%	9	131.25%
4	45.04%	16	180.16%
5	44.80%	25	224.00%
6	46.51%	36	279.06%
7	46.58%	49	326.06%
8	55.21%	64	441.68%
9	70.94%	81	638.46%
10	72.32%	100	723.20%

Note: $\sum x_i = 55$; $\sum y_i = 510.32\%$; $\sum x_i^2 = 385$; $\sum x_i y_i = 3072.42\%$

Result: from Table 3, we can get the following result.

$$b = \frac{(\sum x_i)(\sum y_i) - n(\sum x_i y_i)}{(\sum x_i)^2 - n(\sum x_i^2)} = \frac{(55 \times 510.32\%) - (10 \times 3072.42\%)}{55^2 - (10 \times 385)} = 3.22\%$$

$$a = \frac{\sum y_i - b(\sum x_i)}{n} = \frac{510.32\% - (3.22\% \times 55)}{10} = 33.32\%$$

$$y = a + bx = 33.32\% + 3.22\% \times 11 = 68.74\%$$

That is to say, the predicting data of high-quality employment rate of graduates participating in scientific researches in 2020 is 68.74%.

4.2.2 Prediction on high-quality employment rate of overall graduates in 2020

Table 4. Calculation on related data of overall graduates' employment from 2010 to 2019 Unit: percentage

x_i	y_i	x_i^2	$x_i y_i$
1	32.00%	1	32.00%
2	34.07%	4	68.14%
3	33.06%	9	99.18%
4	33.55%	16	134.20%
5	36.29%	25	181.45%
6	34.40%	36	206.40%
7	32.75%	49	229.25%
8	35.16%	64	281.28%
9	50.71%	81	456.39%
10	51.33%	100	513.30%

Note: $\sum x_i = 55$; $\sum y_i = 373.32\%$; $\sum x_i^2 = 385$; $\sum x_i y_i = 2201.59\%$

Result: we can get the following result from Table 4.

$$b = \frac{(\sum x_i)(\sum y_i) - n(\sum x_i y_i)}{(\sum x_i)^2 - n(\sum x_i^2)} = \frac{(55 \times 373.32\%) - (10 \times 2201.59\%)}{55^2 - (10 \times 385)} = 1.79\%$$

$$a = \frac{\sum y_i - b(\sum x_i)}{n} = \frac{373.32\% - (1.79\% \times 55)}{10} = 27.49\%$$

$$y = a + bx = 27.49\% + 1.79\% \times 11 = 47.18\%$$

That is to say, the predicting data of overall graduates' high-quality employment rate in 2020 is 47.18%.

5 Conclusion

Firstly, based on the least square approximation algorithm and historical empirical data, taking the civil engineering major of this university as an example, the predicting data of high-quality employment rate of graduates participating in scientific researches and overall graduates' high-quality employment rate in 2020 are 68.74% and 47.18% respectively. Secondly, the condition for math algorithm's establishment is that the proportion of graduates participating in scientific research shows a weak linear growth trend year by year on the whole. Thirdly, only when the "high quality employment rate of graduates participating in scientific research" in the previous years reaches the value listed in the table, can the forecast value of "overall high quality employment rate of graduates" in this year be calculated. That is to say, "weak sequential" rational equilibrium exists between these two items. Fourthly, this prediction algorithm is only a theoretical one. Real employment and formation of related data are still influenced by various kinds of interior and exterior elements.

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