Higher Vocational Students' Innovation and Entrepreneurship Ability Demand Prediction

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Abstract—The new era background and new social background put forward higher goals for the cultivation of innovative talents. The accurate prediction of the demand for innovation and entrepreneurship vocational ability of higher vocational students provides an important reference for higher vocational educators to formulate refined innovation and entrepreneurship education management strategies, more balanced allocation of limited innovation and entrepreneurship education resources, and make more scientific innovation and entrepreneurship education decisions. This paper studies the prediction of innovation and entrepreneurship vocational ability demand of higher vocational students under the background of digital informatization and theoretically discusses the demand for innovation and entrepreneurship vocational ability of higher vocational students and its connotation. It constructs the demand prediction framework of innovation and entrepreneurship vocational ability of higher vocational students for data identified on the Knowledge Retrieval Engine or High-quality Knowledge Q&A and Sharing Community, and develops the collection and use methods of students' innovation and entrepreneurship resource retrieval data. It makes the feature selection of the keyword sequence and the corresponding time lag sequence selected by the higher vocational students' innovation and entrepreneurship resource retrieval and builds the prediction model of the vocational ability demand for innovation and entrepreneurship of higher vocational students. Experimental results verify the effectiveness of the proposed model.

Keywords—digital informatization, data mining, higher vocation, vocational ability in innovation and entrepreneurship, ability demand prediction

1 Introduction

At present, the wave of informatization characterized by digitalization, networking and intelligence is prevailing the world, promoting mankind to officially enter the digital information society [1–7]. The rapid development of information technology has had a major impact on all industries in society, not only changing human production and lifestyle [8–12], but also bringing about major changes in thinking and learning methods, and the new era background and new social background put forward higher goals for the cultivation of innovative talents [13–17]. In response to the development of the information society, cultivating innovative and entrepreneurial talents to meet the development needs of the new era has become an inevitable requirement and realistic choice for the development of higher vocational education [18, 19]. The accurate prediction of the demand for innovation and entrepreneurship vocational ability of higher vocational students provides an important reference for higher vocational educators to formulate refined innovation and entrepreneurship education management strategies, more balanced allocation of limited innovation and entrepreneurship education resources, and make more scientific innovation and entrepreneurship education decisions [20–23]. Based on the performance of different terminal retrieval engine data in the demand prediction of innovation and entrepreneurship vocational ability of higher vocational students, it provides empirical evidence for more accurate prediction of innovation and entrepreneurship vocational ability demand of higher vocational students.

In order to make the cultivation of innovation and entrepreneurship talents in the logistics industry more targeted, according to the analysis of the demand for innovation and entrepreneurship talents in the logistics industry, Shi [24] builds the corresponding innovation and entrepreneurship education system, which is composed of two subsystems, the in-class system and the extracurricular system, with clear goals, distinctive module characteristics, strong operability and strong reference. Relevant practices based on this system have achieved remarkable results. The in-depth development of the Internet has made communication around the world convenient and fast, all kinds of information can be obtained on the network, various industries have achieved rapid development, and the education industry naturally needs to keep up with the pace of the times to adapt to the new normal of development. The innovation and entrepreneurship ability training path of college students in reference [25] will be optimized according to Internet technology. Practice proves that the innovation and entrepreneurship talent training path optimized in this paper can improve students' educational ability and guide students' innovation and entrepreneurship, so as to realize the development of ideological and political education in colleges and universities. Li [26] uses literature, questionnaire survey, logical analysis and other methods to explore the internal logical relationship between the integration of the two education models and students' employability, put forward reasonable suggestions for optimizing talent training programs, realize the deep integration of the two education models, and help higher vocational students improve their employability. With the increasing popularity of education informatization and the emergence of intelligent learning spaces, artificial intelligence, as an important part of smart campuses, makes teacher teaching and student learning more accurate and efficient. With the goal of "technology integration, discipline integration, and teacher-student application integration", Zhao [27] analyzes the existing problems in innovation and entrepreneurship education, promotes the improvement of college students' innovation and entrepreneurship ability, and provides a strong guarantee for colleges and universities to deepen the reform of innovation and entrepreneurship education.

At present, the application of artificial intelligence algorithms in assisting the decision-making of higher vocational students' innovation and entrepreneurship vocational ability improvement is relatively lacking, and relevant research is lacking in the mining of a large amount of historical data, the elimination of risk interference of special innovation and entrepreneurship projects, the construction of user preference feature sets and the improvement of demand prediction models, resulting in insufficient scientific research results. In view of this, this paper puts forward a targeted method for predicting the demand for innovation and entrepreneurship vocational ability of higher vocational students under the background of digital informatization, establishes a bridge between the decision-making process and ability demand of higher vocational students' innovation and entrepreneurship vocational ability improvement, improves their ability improvement efficiency, and makes their innovation and entrepreneurship vocational ability closer to their actual work or participation in innovation and entrepreneurship projects. In Chapter 2, this paper theoretically discusses the needs and connotations of innovation and entrepreneurship vocational ability of higher vocational students. In Chapter 3, this paper constructs the demand prediction framework of innovation and entrepreneurship vocational ability of higher vocational students for data identified on the Knowledge Retrieval Engine or High-quality Knowledge Q & A and Sharing Community, and develops the collection and use methods of students' innovation and entrepreneurship resource retrieval data. It makes the feature selection of the keyword sequence and the corresponding time lag sequence selected by the higher vocational students' innovation and entrepreneurship resource retrieval and builds the prediction model of the vocational ability demand for innovation and entrepreneurship of higher vocational students. Experimental results verify the effectiveness of the proposed model.

2 Demand prediction framework and modeling of innovation and entrepreneurship vocational ability of higher vocational students

This paper builds a framework for predicting the demand for innovation and entrepreneurship vocational ability of higher vocational students identified by Knowledge Retrieval Engine or High-quality Knowledge Q&A and Sharing Community data, as shown in Figure 1, and evaluates the predictive performance of the innovation and entrepreneurship vocational ability demand prediction model of higher vocational students under different data sources.

First, collect two types of data from the Knowledge Retrieval Engine and the High-quality Knowledge Q&A and Sharing Community, namely, the retrieval data of the innovation and entrepreneurship resource retrieval and learning times of students with a unified job or the same innovation and entrepreneurship project and the search keywords related to the innovation and entrepreneurship resource. Figure 2 shows several ways to use the data retrieved by students' innovation and entrepreneurship resources.

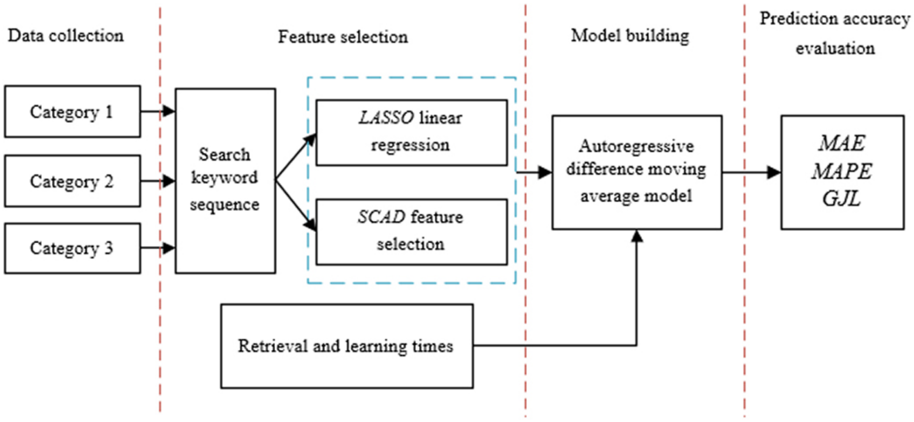


Fig. 1. Demand prediction framework for innovation and entrepreneurship vocational ability of higher vocational students

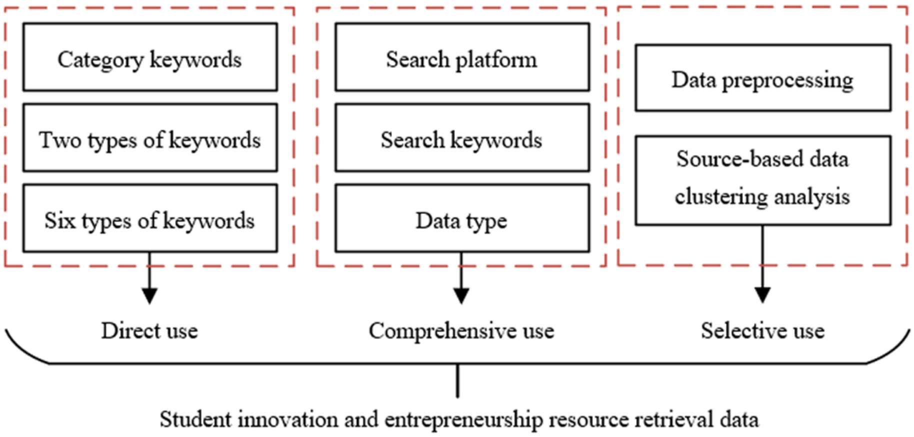


Fig. 2. Use of student innovation and entrepreneurship resource retrieval data

Fig. 3. Influencing factors of innovation and entrepreneurship vocational ability of higher vocational students

Figure 3 shows the influencing factors of the vocational ability of innovation and entrepreneurship of higher vocational students. The influencing factors in Figure 3 are compared and extracted, and the six elements related to the professional ability of innovation and entrepreneurship that should be considered for the search keywords are summarized as "quality and will, learning ability, thinking ability, observation ability, and practical ability". The data obtained are divided into three categories: search through knowledge search engine, search through High-quality Knowledge Q&A and Sharing Community, and aggregate search from all sources by source category.

Then, this paper uses the LASSO linear regression and SCAD feature selection methods to select the selected keyword sequence and the corresponding time lag sequence for the retrieval of innovation and entrepreneurship resources of higher vocational students, respectively, and selects the search keywords with the strongest impact on improving the innovation and entrepreneurship vocational ability of higher vocational students while reducing the dimensionality of the sample data.

Assuming that the dependent variable in LASSO linear regression is represented by B, the explanatory variable is represented by A, the error term is represented by ρ, and the regression coefficient is represented by $\gamma = (\gamma_1, \gamma_2, \gamma_3, \ldots, \gamma_C)^T$, the following feature selection model can be constructed:

$$B = A\gamma + \rho \tag{1}$$

The matrix form of B and A is represented as follows:

$$B = \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_M \end{pmatrix}, A = (a_1, a_2, a_3, \ldots, a_M)^T = \begin{pmatrix} a_{1,1} & a_{1,2} & \ldots & a_{1,c} \\ a_{2,1} & a_{2,2} & \ldots & a_{2,c} \\ \vdots & \vdots & \ddots & \vdots \\ a_{M,1} & a_{M,2} & \ldots & a_{M,p} \end{pmatrix}_{M\times c} \tag{2}$$

Assuming that observed values of B and A in the i-th group are represented by b_i and a_i, then the regression coefficients can be estimated based on the least squares method:

$$\hat{\gamma} = \arg\min_{\gamma} \sum_{i=1}^{M} (b_i - a_i^T \gamma)^2 \tag{3}$$

In order to obtain a more accurate feature, this paper introduces the penalty term $c\mu(\gamma_j)$, assuming that the adjustment parameters used to adjust the fit of the model and the number of variables are represented by $\mu \in [0, +\infty]$, then the above equation can be updated as:

$$\hat{\gamma} = \arg\min_{\gamma} \sum_{i=1}^{M} (b_i - a_i^T \gamma)^2 + \sum_{j=1}^{c} c\mu(\gamma_j) \tag{4}$$

Choosing the right adjustment parameters can avoid the problems of overfitting and "high-dimensional curse" of the model. In general, smaller μ is, models tend to set more variables; larger μ is, models tend to set fewer variables. L_1 regularization occurs when $c\mu(\gamma_j) = \mu|\gamma_j|^u$, u equals 1, then LASSO regresses. Based on the "cv.glmnet" function of the "glmnet" package, this paper selects the features of LASSO under the cross-verification of the selected keyword sequence and the corresponding time lag sequence for innovation and entrepreneurship resources of higher vocational students.

Unlike LASSO linear regression, the SCAD feature selection method has Oracle properties. Assuming that the adjustment parameters are represented by $\mu \in [0, +\infty]$ and $x \in [2, +\infty]$, the penalty term for this method is defined by the following equation:

$$c\mu(\gamma_j) = \begin{cases} \mu\left|\gamma_j\right|, \left|\gamma_j\right| \in [0, \mu) \\ \dfrac{\left|\gamma_j\right|^2 - 2x\mu\left|\gamma_j\right| + \mu^2}{2(x-1)}, \left|\gamma_j\right| \in [\mu, x\mu) \\ \dfrac{(x+1)\mu^2}{2}, \left|\gamma_j\right| \in [x\mu, +\infty) \end{cases} \tag{5}$$

Finally, based on the autoregressive difference moving average model, this paper constructs a demand prediction model for innovation and entrepreneurship vocational ability of higher vocational students.

Autoregressive difference moving average model has great flexibility and strong predictive performance. Assuming that the difference function $\Delta b_o = b_o - b_{o-1}$ is represented by Δ, the rank of the difference determined by the unit root number of the improvement level of innovation and entrepreneurship vocational ability of higher vocational students is represented by c, the error term is represented by ρ_o, the lag of the i period is represented by i, and the constant is represented by λ, ψ_i and ω_i, the following equation gives the $ARIMA(c,e,w)$ model expression:

$$\Delta^e b_o = \lambda + \sum_{i=1}^{c} \psi_i \Delta^e b_{o-i} + \rho_o + \sum_{i=1}^{w} \omega_i \rho_{o-i} \tag{6}$$

It's assumed that the amount of lag for different search keywords is represented by $a_{i,o-j}$, and the lag in j period is represented by j. When the modeling process includes the keyword search volume of innovation and entrepreneurship resources, the built prediction model is improved as:

$$\Delta^e b_o = \lambda_o + \sum_{i=1}^{c} \psi_i \Delta^e b_{o-i} + \sum_{i=1}^{m} \sum_{j=1}^{s} \beta_{ij} a_{i,o-j} + \rho_o + \sum_{i=1}^{w} \omega_i \rho_{o-i} \tag{7}$$

The time-lagged sequence corresponding to the selected keyword sequence in the innovation and entrepreneurship resource retrieval of higher vocational students will be selected by the SCAD feature selection method. It's essential to count the number of searches made by knowledge search engines, the search volume conducted through High-quality Knowledge Q&A and sharing communities, and the total searches of all sources as explanatory variables. It's also critical to count the number of different search keywords when the search volume of the knowledge search engine and the search volume through the High-quality Knowledge Q&A and Sharing Community are used as explanatory variables. In addition, the Pearson correlation coefficient is used to determine the maximum lag time of the impact of the retrieved data on the improvement of the innovation and entrepreneurship vocational ability of higher vocational students, and the lag order of different search keywords in the constructed prediction model. This paper uses the "*auto.arima*" function of the "*prediction*" package to predict and estimate the demand for innovation and entrepreneurship vocational ability of higher vocational students.

This paper uses both MAE and MAPE to measure the prediction error of the demand for innovation and entrepreneurship vocational ability of higher vocational students. Let b_i represent the actual weekly number of student innovation and entrepreneurship resource retrievals and learning, b_i* represents the predicted value of weekly student innovation and entrepreneurship resource retrievals and learning times, MAE and MAPE calculation formulas are given by the following formula:

$$MAPE = \frac{1}{m}\sum_{i=1}^{m}\left|b_i - b_i^*\right| \tag{8}$$

$$MAPE = \frac{1}{m}\sum_{i=1}^{m}\frac{\left|b_i - b_i^*\right|}{b_i} \tag{9}$$

At the same time, GJL is introduced to calculate the improvement rate of the model before and after improvement, and the calculation formula is as follows:

$$GJL = \frac{MAPE(Model_2) - MAPE(Model_1)}{MAPE(Model_2)} \times 100\% \tag{10}$$

3 Experimental results and analysis

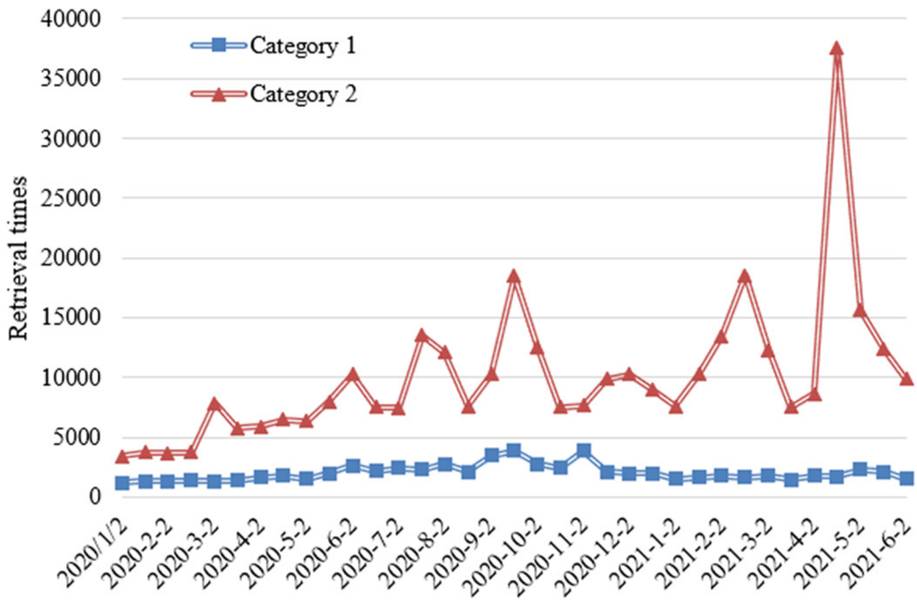


Fig. 4. Weekly search volume on the Knowledge Retrieval Engine and Knowledge Q&A and Sharing Community

The data sample set of the study spans from January 2020 ~ June 2021. Specifically, model training uses the data of the first 12 months to build a test sample set from the remaining 6 months of data samples. Figure 4 shows the weekly search volume on the Knowledge Retrieval Engine and the Knowledge Q&A and Sharing Community.

Table 1. Prediction error under different feature selection methods

MAE	The Method	LASSO	SCAD
1	1757.42	1952.72	2172.65
2	1839.83	2149.63	2247.41
3	1940.91	2301.06	2362.42
6	2027.28	2486.42	2503.16
9	1779.67	2272.85	2913.54
12	1927.83	2478.03	2462.75
MAPE	**The Method**	**LASSO**	**SCAD**
1	0.2823	0.2765	0.3481
2	0.3082	0.3356	0.4395
3	0.2951	0.3331	0.4692
6	0.2489	0.2823	0.3307
9	0.2441	0.2703	0.4223
12	0.1852	0.2289	0.2231

Table 2. Comparison of prediction accuracy of prediction models under different data sources

MAE	Source 1	Source 2	Source 3	Source 4
1	1862.37	3016.31	2332.12	2615.32
2	1951.89	3695.46	2421.26	2891.53
3	2098.34	3715.53	2741.35	3086.75
6	2172.61	4431.95	2884.21	3132.57
9	2015.42	9365.27	2945.01	3265.09
12	2083.96	3808.51	2735.21	3264.28
MAPE	**Source 1**	**Source 2**	**Source 3**	**Source 4**
1	0.2981	0.4331	0.3124	0.3485
2	0.3354	0.5492	0.4014	0.4256
3	0.3223	0.5456	0.4047	0.4381
6	0.2647	0.5432	0.3451	0.3875
9	0.2776	0.4875	0.3641	0.3954
12	0.1892	0.2936	0.2097	0.2521

The variables selected by different feature selection methods are used to construct a prediction model for the demand for innovation and entrepreneurship vocational ability of higher vocational students, and the prediction error is shown in Table 1. It can be seen from the results that the feature selection results of the LASSO linear regression and SCAD feature selection methods are synthesized, and the prediction performance of the extracted feature variables is the best. In contrast, the prediction error of a single LASSO and SCAD feature selection method is large, because a single method tends to ignore some valuable feature variables and mistake some features without value as important features. Therefore, it is verified that the proposed method is the optimal feature selection method for the prediction of the demand for innovation and entrepreneurship vocational ability of higher vocational students.

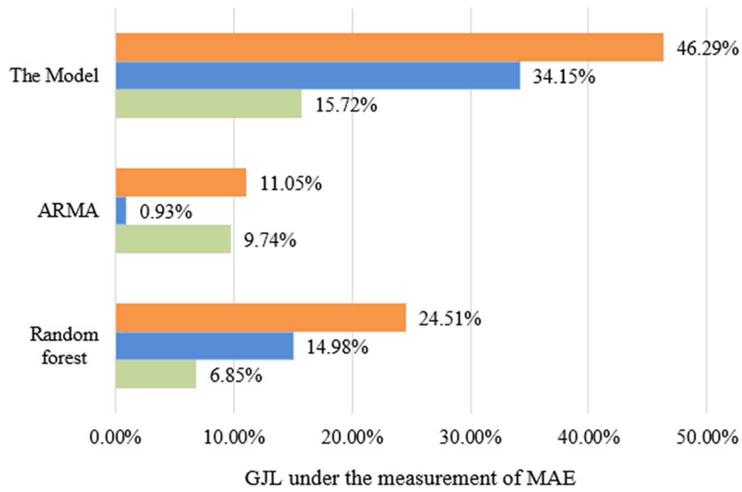
Table 2 lists the comparison results of prediction accuracy evaluation of the prediction models under different data sources, including retrieved data from Knowledge Retrieval Engine as explanatory variables (Source 1); retrieved data from the Q&A and sharing community as explanatory variables (Source 2); from the above two aspects of the overall search volume as explanatory variables (Source 3); and the simultaneous introduction of prediction models using Knowledge Retrieval Engines and Knowledge Q&A and Sharing Community search volumes as independent explanatory variables (Source 4).

By comparing the prediction results, the following conclusions can be drawn. The prediction model derived from the data retrieved by the Knowledge Retrieval Engine significantly outperforms the prediction model derived from the data retrieved by the Knowledge Q&A and Sharing Community. Second, the prediction model that introduces Knowledge Retrieval Engines to retrieve data outperform models that use the overall search volume from both aspects as explanatory variables. At the same time, for the prediction model that uses the Knowledge Retrieval Engine and the Knowledge Q&A and Sharing Community to retrieve data as independent explanatory variables and introduces them at the same time, its performance is not better than the model that only uses the Knowledge Retrieval Engine to retrieve data.

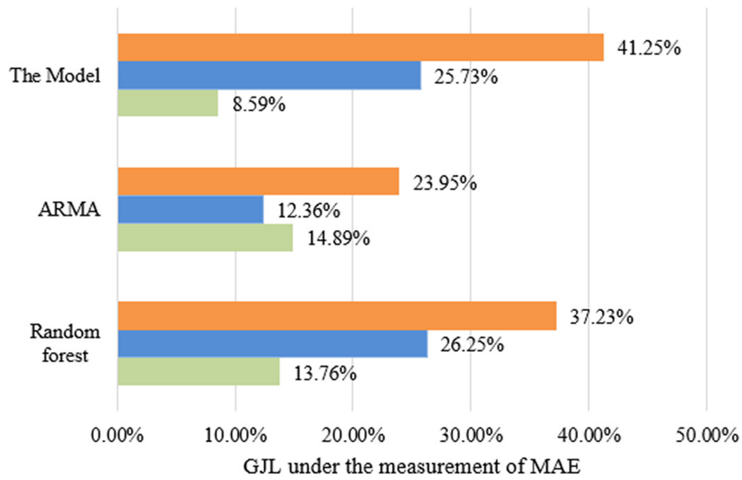
Table 3. Comparison of prediction performance of different models

MAE	**ARMA**	**SVR**	**BP Neural Network**	**Random Forest**
1	48.23%	51.27%	50.21%	47.10%
2	47.23%	53.24%	51.20%	45.11%
3	43.62%	56.37%	53.07%	40.29%
6	51.27%	55.93%	52.23%	46.45%
9	52.95%	53.40%	53.62%	46.77%
12	51.52%	54.49%	53.75%	48.13%
MAPE	**ARMA**	**SVR**	**BP Neural Network**	**Random Forest**
1	37.25%	41.32%	52.65%	3715%
2	42.57%	45.37%	53.71%	42.65%
3	41.56%	43.36%	56.95%	47.21%
6	54.55%	42.47%	57.11%	52.74%
9	50.81%	49.54%	52.25%	52.34%
12	49.57%	43.67%	53.01%	47.05%

Table 3 lists the prediction improvement rate GJL of the best prediction model using the Knowledge Retrieval Engine to retrieve data as an explanatory variable, compared with other prediction models. The models included ARMA model, SVR model, BP neural network model, and random forest. It can be seen from the comparison results that compared with the three models, the average error improvement rate of this model using Knowledge Retrieval Engine to retrieve data as explanatory variables reaches about 50%. Through comparison, it can be noted that compared with ARMA model, SVR model, BP neural network model, and random forest, the proposed model using Knowledge Retrieval Engine to retrieve data as explanatory variables has better prediction accuracy.



(a)



(b)

Fig. 5. Average prediction improvement rate of the prediction models

Figure 5 shows the average prediction improvement rate of the prediction models under different feature selection. The data retrieved from the Knowledge Retrieval Engine is used as the standard index for prediction performance, and compared with the prediction models of other three data sources to calculate the accuracy improvement of the data retrieved by the Knowledge Retrieval Engine on the prediction of the vocational ability of higher vocational students in innovation and entrepreneurship. The largest error improvement rate is that when using the prediction model built in this paper, the error improvement rate of the prediction model using the Knowledge Retrieval Engine to retrieve data is more than 45% compared with the prediction model using Knowledge Q&A and Sharing Community to retrieve data. The smallest error improvement rate is the comprehensive feature selection result using the LASSO linear regression and SCAD feature selection methods, which is more than 10% compared to the prediction model using a single feature selection result.

4 Conclusion

This paper studies the prediction of innovation and entrepreneurship vocational ability demand of higher vocational students under the background of digital informatization and theoretically discusses the demand for innovation and entrepreneurship vocational ability of higher vocational students and its connotation. It constructs the demand prediction framework of innovation and entrepreneurship vocational ability of higher vocational students for data identified on the Knowledge Retrieval Engine or High-quality Knowledge Q&A and Sharing Community, and develops the collection and use methods of students' innovation and entrepreneurship resource retrieval data. It makes the feature selection of the keyword sequence and the corresponding time lag sequence selected by the higher vocational students' innovation and entrepreneurship resource retrieval and builds the prediction model of the vocational ability demand for innovation and entrepreneurship of higher vocational students. It summarizes weekly search volumes on the Knowledge Retrieval Engine and the Knowledge Q&A and Sharing Community. The variables selected by different feature selection methods are used to construct a prediction model for the demand for innovation and entrepreneurship vocational ability of higher vocational students, and provides the prediction error situation. It is verified that the feature selection method in this paper is the optimal feature selection method for the prediction of the demand for innovation and entrepreneurship vocational ability of higher vocational students. The comparison results of prediction accuracy evaluation of prediction models under different data sources are listed, and three conclusions are given. This paper lists the prediction improvement rate GJL of the prediction model with the best performance compared to other prediction models using the Knowledge Retrieval Engine to retrieve data as an explanatory variable. It is verified that the proposed model using the Knowledge Retrieval Engine to retrieve data as explanatory variables has better prediction accuracy. It shows that the average prediction improvement rate of the prediction model under different feature selection conditions. It is verified that the smallest error improvement rate is the comprehensive feature selection result using the LASSO linear regression and SCAD feature selection methods.

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