Long-Term Forecast of Regional Economy Based on Least Squares Support Vector Machine

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Keywords: Least Squares Support Vector Machine, Regional Economy, Medium- and Long-Term Forecasting, Support Vector Machine.

Abstract: Regional economic growth is a demand-led change. By reasonably forecasting and studying the patterns and operating mechanisms of economic growth changes in a specific range of regions, we will promote the sustainable growth of regional economy and society. In order to address the shortcomings of the existing research on regional economic forecasting in the medium and Long-Term, this paper briefly discusses the index system and sample data of the forecasting model proposed in this paper based on the least squares support vector machine (LLSSVM) and regional economic forecasting methods. The design of the forecasting model is also discussed, and the results of the least squares support vector machine for medium- and Long-Term regional economic forecasting are finally analyzed experimentally. The experimental data show that the error between the prediction results of least squares support vector for a city's economic GDP and the actual results is small, and its accuracy rate for a city's economic GDP prediction is about 96.5% on average, which is significantly better than the other two prediction models. Therefore, it is verified that the game model simulation based on ant colony algorithm performs better.

1   INTRODUCTION

There is a close relationship between regional economic development and national economic development and people's social living standards, and the correct prediction and analysis of the law of economic development changes in the region is beneficial to the continuous development of the national economy and regional economy.

Nowadays, an increasing number of scholars have conducted a large number of studies in medium and Long-Term forecasting of regional economies through various technical and systematic tools and have achieved some results through practical research. Archit derives a general differential equation describing the cyclical and trend components of Long-Term economic growth. The equation is based on an induced investment nonlinear gas pedal model. A method is proposed to solve the approximate solution of the nonlinear differential equation by decomposing the solution into a rapidly oscillating business cycle and a slowly varying trend using the KBM averaging method. The model gives rough estimates of the threshold at

which the system destabilizes and falls into a crisis recession and is one of the main results of the model. The model is used to forecast the macroeconomic dynamics of the United States in the sixth Kondratieff cycle (2018-2050). For this forecast, Archit uses a fixed productive capital function dependent on the long-run Kondratieff cycle and the medium-run Juglar and Kuznets cycles. More accurate forecasting of the timing of crises and recessions is based on the accelerated log-cycle oscillation model (Archit 2018). Salimova G proposes a model for forecasting socio-economic trends in a region. The model envisages the construction of three = models: matrix predictor, autoregressive model and binary choice logit model. This approach ensures adequate reproduction of the system dynamics of regional socio-economic development indicators. It is also tested by specific examples that illustrate the opportunities of multidimensional economic and mathematical modeling of difficult socio-economic phenomena and processes. The development of the model provides for the implementation of multivariate forecasting calculations (Salimova G 2022). The aim of Greyling L research is to develop an appropriate

542

mathematical model for Long-Term forecasting of technological progress and economic growth in the digital age. To achieve its goal, the Schumpeter-Kondratieff theory of innovation and cycles is the most suitable economic-technical cluster of economic development for Long-Term forecasting of technological progress and economic growth. Greyling L developed an information model for forecasting technological progress based on the growth rate of endogenous technological information in the economy. It also gives the main regimes of producing technological information corresponding to the era of information and digital economy, as well as the Lagrange's theorem that generates them. The model is validated with the information LW of the U.S. economy from 1982-2018, with highly accurate approximations to both technological progress and economic growth (Greyling L 2022). Although there is a wealth of existing research on regional economic forecasting in the medium and Long-Term, there are certain shortcomings in regional economic forecasting in the medium and Long-Term based on least squares support vector machines.

In this paper, based on the established least squares support vector machine (LLSSVM) regression forecasting model, an evaluation index system for regional economic forecasting is constructed with the economic development of a city as the background of the empirical study, and the selected sample data are screened for indicators and the data set is pre-processed for normalization. The least squares support vector machine (LLSSVM) and the characteristics and properties of regional economic development are used to describe in detail the basis for the establishment of the forecasting model. The prediction accuracy of LLSSVM for regional economy is compared with PCA and SVM, and the results show that the prediction accuracy based on LLSSVM) is better than that of PCA and SVM models.

2 MEDIUM- AND LONG-TERM FORECASTING OF REGIONAL ECONOMY BASED ON LEAST SQUARES SUPPORT VECTOR MACHINE

2.1 Least Squares Support Vector Machine (LLSSVM)

LLSSVM adopts the empirical risk minimization criterion and uses kernel functions to solve nonlinear

regional economic forecasting problems, which can be solved as linear forecasts in the new economic characteristics (Sun F 2022).

At this point the decision function can be expressed as:

$$k(u) = h \cdot \vartheta(k) + c \qquad (1)$$

where h is a vector of regional economic weights and c is an offset. The structural risk minimization principle is used to find the value of this vector.

The LLSSVM optimization problem can be expressed as:

$$\min_{h,c,v} W(h,c,v) = \frac{1}{2}\|h\|^2 + \frac{1}{2}\lambda\sum_{i=1}^{X} v_i^2 \ (i=1,2,...X)$$

$$(2)$$

where, λ is the penalty parameter and v_i denotes the prediction error. From the above equation, it can be seen that the loss function is directly defined in the least squares support vector machine as the sum of squares of the errors (Iliovits M 2022).

The expression of the prediction model for nonlinear regression can be written as:

$$k(u) = \sum_{j=1}^{X} \beta_i G(u_i, u_j) + c \qquad (3)$$

In the above equation, β_i is the multiplier of regional economy and $G(u_i, u_j)$ is the kernel function, which satisfies the conditions of regional economic development. The kernel function chosen in this paper is

$$G(u_i u_j) = \exp(-\frac{\|u_i - u_j\|^2}{2\varpi^2}).$$

2.2 Regional Economic Forecasting Methods

Regional economic forecasting can be divided into different categories according to different methods (Virtanen H 2022).

(1) According to the scope involved in economic forecasting, it can be divided into macro and micro economic forecasting. Macroeconomic forecasting generally refers to forecasting based on the national economy and the scope of operation of regional units. Microeconomic forecasting refers to forecasting on the basis of the scope of operation of

production units (Klopp R N 2022).

(2) Long-Term, medium- and Long-Term economic forecasts, short-term and near-term forecasts are classified according to the length of the forecast period. Long-term economic forecasting refers to making forecasts for more than five years. Medium-term economic forecasting refers to forecasting for one to five years (Raj A 2022).

(3) Static and dynamic economic forecasts can be classified according to the temporal state of the forecast. Static economic forecasting is based on the expectation of the cause-effect relationship arising from macro things in a region (Falahat M 2022). Dynamic economic forecasting, on the other hand, refers to the prediction of future economic development based on the course and dynamics of macro things generated in a region.

3 INVESTIGATION AND STUDY OF REGIONAL ECONOMIC FORECASTING IN THE MEDIUM AND Long-Term BASED ON LEAST SQUARES SUPPORT VECTOR MACHINE

3.1 Regional Economic Forecasting Index System

The index system studied in this paper is based on the composition of gross domestic product (GDP), and the factors affecting the regional economic growth include three aspects: investment, consumption, and import and export. Economic

growth is the result of the configuration of these main factors among different organizations (Slama F B 2022).

■ Investment: fixed asset investment and real utilization of foreign capital.

■ Consumption: In this paper, the total retail sales of consumer goods is chosen to reflect the level of consumption of the population, and government fiscal expenditure is chosen to reflect government consumption.

■ Import and export: the import and export of foreign trade are selected to reflect the import and export situation.

■ Resources: total energy consumption, investment in environmental protection, deposit balance of financial institutions, and investment in education.

3.2 Data Selection

The data set of this paper is the bottom data of business and industry business system of a provincial industrial and commercial bureau, and the time span of the data set is from 2011 to 2021, among which there are 87641 records in the original data set of industrial and commercial data of a city, in order to improve the prediction accuracy of the model, the data set after pan-Chinese processing is shown in Table 2, this paper takes the data from 2011-2021 as the training set, and takes the data from 2017 and In this paper, the data from 2011-2021 are used as the training set, and the data from 2017 and 2021 are used as the test set for testing the prediction model (Caputo F 2022)

Table 1: Selected data after processing.

Corporate logo		Enterprise type	Enterprise scale	Area	Industrial division
50221198BABA		H	1	02	005
50221198BABA		L	3	04	006
50221198BABA		F	2	02	006
50221198BABA		Y	2	02	005
50221198BABA		G	3	04	005

4 RESEARCH ON THE APPLICATION OF REGIONAL ECONOMIC MEDIUM- AND LONG-TERM FORECASTING BASED ON LEAST SQUARES SUPPORT VECTOR MACHINE

4.1 Construction of Regional Economic Medium and Long-Term Forecasting Model Based on Least Squares Support Vector Machine

According to the characteristics of the regional economy in the medium and Long-Term, it is necessary to consider the characteristics of the medium and Long-Term development stages when building the forecasting model. According to the actual regional economic development in recent years, the overall target of economic development of a city in 2021 is predicted, and it is necessary to grasp the two points of bottom limit and high limit. And in the process of LSSVM forecasting model establishment, two penalty parameters and activation functions need to be determined. If the penalty parameter is small, the phenomenon of under-learning of prediction is likely to occur: if the penalty value is too large, the phenomenon of over-learning of prediction is likely to occur. If the kernel function is too small, the SVM is prone to the risk of overtraining and vice versa. For this reason, a medium- and Long-Term economic forecasting model based on least squares support vector machine is designed as shown in Figure 1.
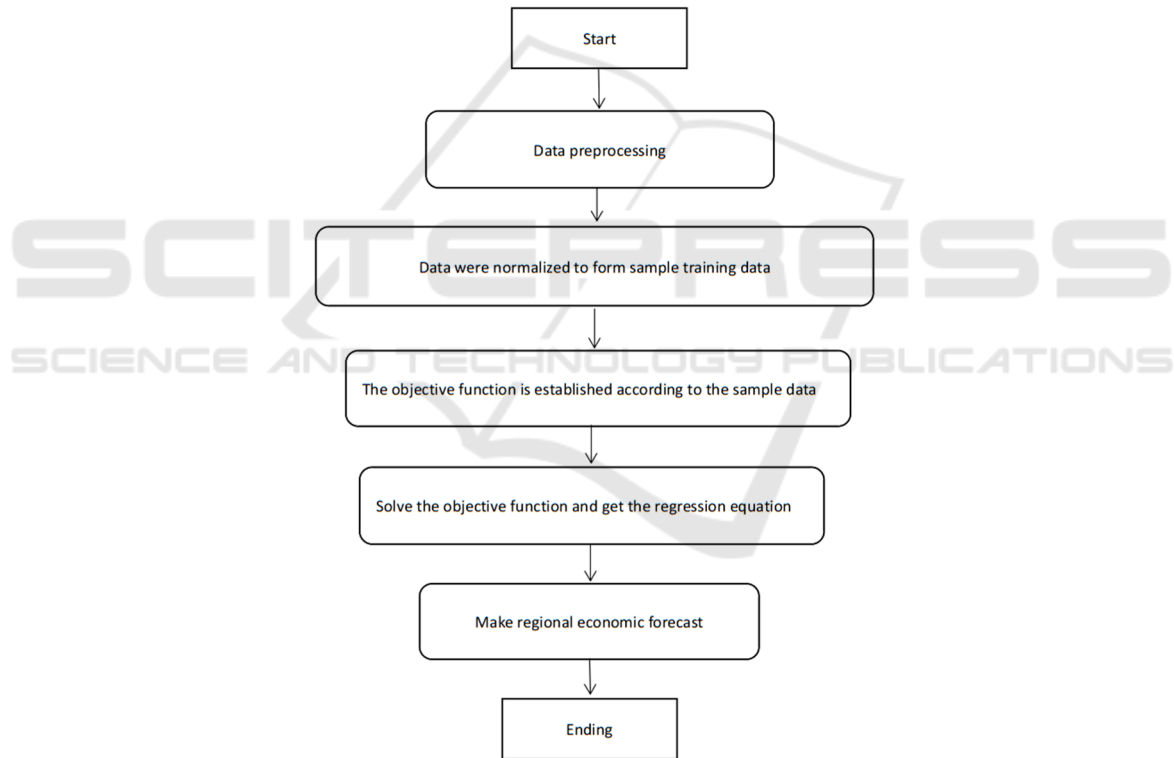

Figure 1: LSSVM prediction model diagram.

After fully studying the principle of LSSVM we can follow the following process to model:

■ Historical regional economic data anomaly data identification and pre-processing.

■ Normalization of historical data to form a training sample matrix.

■ empirically determine the penalty parameters and kernel functions to establish the objective function.

■ Solving the objective function to obtain the regression equation.

■ Forecast the medium- and Long-Term development trend of the regional economy using the obtained regression equation;

4.2 Application of Least Squares Support Vector Machine Based Regional Economic Medium- and Long-Term Forecasting

In order to verify the validity of this paper, two other similar models are introduced for comparison, one is using principal component analysis (PCA) to extract components from the original independent variable data, and then using SVM regression modeling and forecasting; the other is using direct SVM modeling, that is, not extracting components from the original independent variable data, but directly performing SVM regression modeling and forecasting. In order to ensure the validity of the method comparison, the parameters of the latter SVM were chosen to be the same as those of the LSSVM. Then the five sample components obtained after pre-processing were used to build the regression models and to make predictions, so as to obtain the predicted and actual results of the economic GDP from 2017 to 2021 for statistical analysis, and the accuracy of the predictions of the three models was obtained as shown in Figure 2.
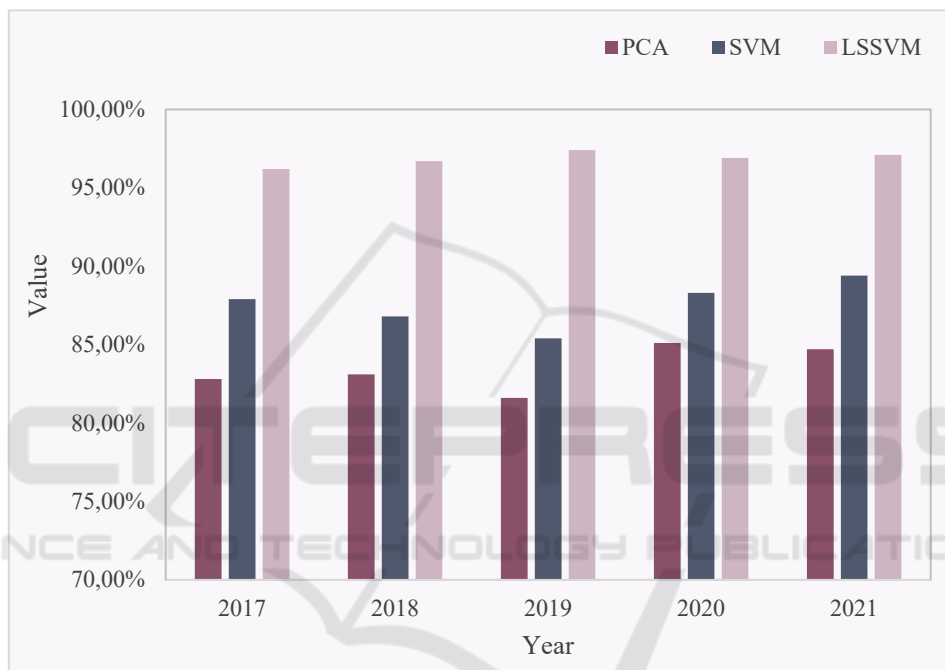

Figure 2: comparison of forecasting accuracy.

From the experimental data in Figure 2, it can be seen that the accuracy of LSSVM's regional economic forecasts from 2017 to 2021 is higher than that of PCA and SVM in general. The accuracy of the PCA and SVM GDP forecasts is only 85.1% on average, while the accuracy of the LSSVM forecasts is 97.4% and 96.9% for 2019 and 2020 respectively. As well as LSSVM has an accuracy of 97.1% in forecasting economic GDP for 2021, the other two models have an accuracy of only 84.70% and 89.40% in forecasting economic GDP, respectively. Therefore, it can be found that the least squares support vector machine proposed in this paper is better than the other two models in predicting the regional economy in the medium and Long-Term, and its superiority of prediction is verified.

5 CONCLUSIONS

In this paper, through an in-depth study of regional economic forecasting methods and least squares support vector machines, an LSSVM model was established based on the relevant data and index system of a city from 2011-2021, and the predicted economic GDP from 2017-2021 was successfully predicted, and the fitting effect was very satisfactory according to the prediction error. Then, the LSSVM model was trained and tested with PCA and SVM models, and the errors of the prediction results and the actual results were statistically analyzed for accuracy comparison. Finally, it is verified that the LSSVM model fits better than the other two models.

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