Data Science in Finance and Economics

http://www.aimspress.com/journal/dsfe

DSFE, 3(1): 1–13.
DOI:10.3934/DSFE.2023001
Received: 17 October 2022
Revised: 03 December 2022
Accepted: 12 December 2022
Published: 06 January 2023

Research article

Analysis and prediction of American economy under different government policy based on stepwise regression and support vector machine modelling

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Abstract: On account of the enormous role of various government policies, it is very important and valuable to find remarkable independent variables from many practical factors of influencing American economy via choosing suitable methods and effective "optimal" models or equations. Based on the American economic data in practice, in order to creatively analyze and predict American economy under two different government policies, we analyze the relationship between each factor and the economy and obtain some greater impact factors to American gross domestic product (in short, GDP) by using a class of stepwise regression, and then we give optimal analysis and predict the influence to American GDP via employing support vector machine models. Further, we establish data comparison to provide beneficial reference for choosing from two different government policies. Finally, we propose some work for future research.

Keywords: optimal analysis; prediction; stepwise regression; support vector machine model; American economy

JEL Codes: C38, C53, O17, P15

Abbreviations: SRA: Stepwise regression analysis; SVMM: Support vector machine modelling; GDP: Gross domestic product; USCE: American construction expenditure; TIFA: Total investment in fixed asset; EUR: Employment/unemployment rate; NIE: Eet income from investment in education; ECE: Education construction expenditure; HE: Hospital expenditure; RLS: Revenue from landscaping service; ETVW: Value of exports to the world; PPHI: Proportion with public health insurance; REPG: Proportion of renewable energy power generation; FT: Financial trade; EP: Environment protection; RES: Renewable energy source; Pc I: The first policy; Pc II: The second policy; PC: Partial correlation;

CST: Collinear statistical tolerance; RELS: Revenue from landscaping service; NIFEI: Net income from investment in education; HCR: Health care reform

1. Introduction

As we all know, different policies adopted by government will lead to different trends in the development of countries, and it is impossible to give specific predictions on the development prospects. See, for example, Zhang (2016) and the references therein. Since the last century, many financial experts and researchers had begun to study this problem. For instance, the government policies adopted by the United States are obviously different in all aspects, which are mainly divided into two levels (Wang (2014); Galam (2021)). For more details, one can refer to (Haughton, et al. (2017); Zhang and Zhang (2020); Zou (2020); Yukang (2020); Hrvoje (2020); Holder (2021)) and the reference materials therein. However, from a macroeconomic point of view, it is a multi-factor problem to analyze the impact of different policies on the economy of different governments. This is challenging and worthy of exploring.

A series of questions need to be considered for studying the impact of different policies on the economy, various government policies have played a huge role in the development of national economy and social development. In recent years, replacement of government policies has attracted widespread attention from all professions (Zhao (2020); Zou and Xie (2020); Xie and Xia (2020); Zhang (2021)). On the one hand, different governments have different governance concepts, and on the other hand, different governments represent the interests of different people in some countries. Different policies adopted to govern a country will lead to different national economic development trends (Hu (2020); Hou (2020); Zeng et al. (2021)).

Since many variables have impact to the economy, it is necessary to determine the independent variables that have a significant impact on the economy, and then to ensure the "optimal" model or equation. In 2020, Knopov and Korkhint (Knopov and Korkhin (2020)) proposed to model the coronavirus infection dynamics using switching regression whose switching points are unknown, described step-by-step process of constructing the regression in time, which is called stepwise regression analysis (in short, SRA) (Gao (2005)), and analyzed dynamics of the coronavirus infection in Ukraine. Thus, we shall adopt SRA to separately analyze the relationship between each factor and the economy under different policies. The basic idea is to introduce variables into the model one by one for testing. When the introduced influence becomes no longer significant, it will be deleted, and then the independent variables which have a significant influence on the dependent variable will be found, so as to screen the independent variables.

Moreover, support vector machine modelling (in short, SVMM) is a supervised machine learning method for binary classification on the strength of statistical learning theory duo to Vapnik (Vapnik (1998)), and it seeks to improve the generalization ability of classifiers by structural risk minimization. As a consequence, the SVMM is often used to investigate prediction problems. In 2021, based on the SVMM integrated with the decomposition and fusion methods, Sun et al. (Sun, et al. (2021)) explored multiclass financial distress prediction. Meanwhile, Narvekar and Guha (Narvekar and Guha (2021)) used three popular machine learning techniques—random forest, support vector machines, and XGBoost to construct forecasting models. Further, in order to improve the accuracy of stock index prediction, Zhou (Zhou (2021)) compared traditional K-fold cross-validation and three cross-validation methods in

the radial basis function support vector regression model. For more related work, see (Hurlbert (2019); Knopov and Korkhin (2020); Mnich, et al. (2020); Zeng et al. (2021); Khanali and Vaziri (2021)) and the reference therein. Through analysis of the effect of different policies, we can basically predict and evaluate their impact on American economy in the short term, the emergence of certain emergencies have an irreversible impact on the economy, such as the epidemic (see Zeng et al. (2021); Khan, et al. (2022)).

Inspired by the above work, we inventively construct optimal result analysis models of the influence for different policies on American economy and predict the influence to American gross domestic product (in short, GDP). The remainder of this paper is organized as follows. In Section 2, we show the selection of variables and solution methods. Under some appropriate assumptions, we give modelling process of SRA analyze the relationship between each factor and American GDP under different policies in several, and through significance test, we acquire some greater impact factors of American practical economy in Section 3. In Section 4, in order to select from different policies, based on principle of SVMM and employing generalized linear classification of binary classification, we propose data comparison and optimal analysis of the influence to American economy, and the influence to American GDP is predicted. Finally, some conclusions and future work are discussed in Section 5.

2. Research design

In order to analyze and predict American economy under government policy of two different levels, we take the United States as an example in this paper, and health care, taxation, foreign trade, education investment, epidemic prevention and control policies are makes different analyses. Based the American economic data in practice, in order to judge, we collect American construction expenditure (in short, USCE), total investment in fixed asset (in short, TIFA), taxation, trade, exports to the world, trade value, immigrant employment/unemployment rate (in short, EUR), net income from investment in education (in short, NIE), education construction expenditure (in short, ECE), hospital expenditure (in short, HE), revenue from landscaping service (in short, RLS), value of exports to the world (in short, ETVW), proportion with public health insurance (in short, PPHI), proportion of renewable energy power generation (in short, REPG), financial trade (in short, FT), environment protection (in short, EP), renewable energy source (in short, RES), epidemic prevention and control of two different policies, i.e., the first policy (in short, Pc I) and the second policy (in short, Pc II).

Applying SRA and SVMM, we devise the following solution process of the entire model to optimally analyze the impact to American GDP for Pc I and Pc II (see Figure 1).

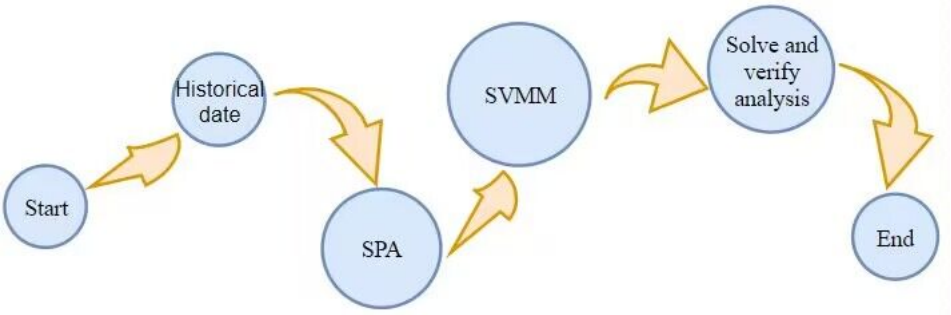

Figure 1. Solving model flow chart.

3. SRA

And then, we shall analyze the influence for Pc I and Pc II on American economy by employing SRA.

The significance of the problem shows that American economy is affected by many factors, and it is necessary to select the most influential factor. Thus, first of all, we put forward the following assumptions:

(A1) The data source is reliable and accurate, ignore abnormal data.
(A2) There are no other factors that affect the economy other than the research factors in the problem.
(A3) The United States will not have major events affecting the economy in the next few years, and the entire society is in a stable state.
(A4) The policy statement will be implemented.

Under the assumptions (A1)–(A4), auto-selection principle will be considered. That is, the most important variable from a large number of selectable variables is chosen and an explanatory template for regression analysis is created. The selection of variables depends on the degree of the effect for the independent variable on the dependent variable. Variables with a high degree of retention are retained, and variables with minor impacts are eliminated. The correlation coefficient constitutes one of the bases for the determination of variables. Furthermore, we select many factors that have a greater impact on American economy and construct a SRA model, which can select and delete factors significantly to facilitate the search for the most effective factors.

Now we are listing the modelling process as follows.

Model 3.1. Step 1. *Choose the independent variable* (*locate the data influence factors* $X_1, X_2, \cdots, X_m$) *and select GDP as the dependent variable to construct the correlation factor matrix.*

$$R = \begin{bmatrix} R_{11} & R_{12} & \cdots & R_{1m} & R_{1y} \\ R_{21} & R_{22} & \cdots & R_{2m} & R_{2y} \\ \cdots & \cdots & \ddots & \cdots & \cdots \\ R_{m1} & R_{m2} & \cdots & R_{mm} & R_{my} \\ R_{y1} & R_{y2} & \cdots & R_{ym} & R_{yy} \end{bmatrix}, \tag{1}$$

where y delegates dependent variable GDP, m is the number of independent variables, R_{ij} *denotes the correlation coefficient of independent variables ith and jth for* $i, j = 1, 2, \cdots, m$, *and* R_{ky} *and* R_{yk} *denote the correlation coefficient of the kth independent variable and the dependent variable y for* $k = 1, 2, \cdots, m$

Step 2. *Based on the correlation coefficient matrix* (1)*, determine the following contribution value of the jth independent variable:*

$$P_j = \frac{R_{jy}^2}{R_{jj}}, \quad \forall j = 1, 2, \cdots, m, \tag{2}$$

which represents the contribution rate of each influencing factor.

According to the calculation of (2)*, for* $l = 1, 2, \cdots, m$, *contribution coefficient of the lth step can be expressed as*

$$P_j^{(l)} = \frac{\left[R_{jy}^{(l-1)}\right]^2}{R_{jj}^{(l-1)}}, \quad \forall j = 1, 2, \cdots, m, \tag{3}$$

here $R_{jy}^{(0)} = R_{jy}$ *and* $R_{jj}^{(0)} = R_{jj}$ *for any* $j = 1, 2, \cdots, m$.

Step 3. *Introduce test to determine whether the variable is eliminated.*

(i) *By comparing with* (3)*, one can obtain the largest contribution rate as follow*

$$P_v^{(l)} = \max\left\{P_j^{(l)} \middle| \, j = 1, 2, \cdots, m\right\}. \tag{4}$$

(ii) *Set a significance level* $\alpha \in [0, 1]$ *and find the critical value* F_α *of F-test. According to the F-test variable and by* (4)*, one can define and obtain the judgment value for the nth independent variable as* (*see Gao (2005)*)

$$F_{out} := \frac{[n - (l+1) - 1] \cdot P_v^{(l)}}{R_{yy}^{(l-1)} - P_v^{(l)}} = \frac{(n - l - 2)P_v^{(l)}}{R_{yy}^{(l-1)} - P_v^{(l)}}, \quad \forall n = 1, 2, \cdots, m. \tag{5}$$

Step 4. *Compare* F_α *with* F_{out} *in* (5) *for determining whether the nth independent variable retains for* $n = 1, 2, \cdots, m$. *If* $F_{out} \leq F_\alpha$*, then the nth independent variable is eliminated. Otherwise, we should reserve the nth independent variable.*

It follows from Model 3.1 that GDP is chosen as a dependent variable and other factors are considered as independent variables $X_1, X_2, \cdots, X_m$. Firstly, data for the problem is collected, the data is analyzed by using SPSS software, and the contribution value of each factor is calculated. Then, we compare the contribution value and select the largest several factors based on testing for significance, and acquire the regression equation. In the loop operation outside the equation, the confidence interval is indicated and the conclusion is drawn.

Using SPSS software, the essential data is carried out SRA, one can get GDP regression standardized residual errors (see Figure 2). According to the histogram in Figure 2, one can see intuitively that the

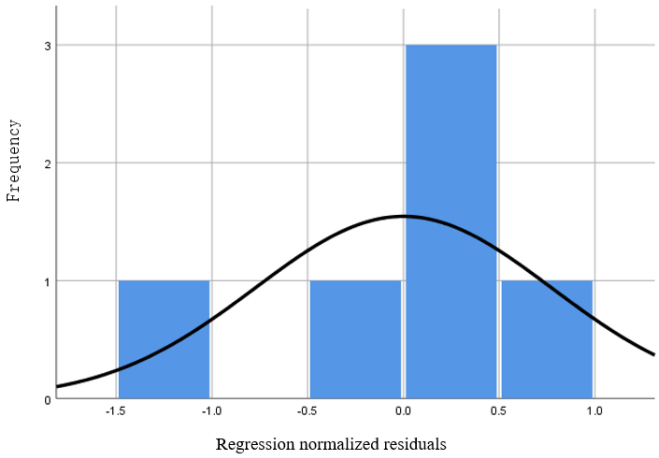

Figure 2. GDP regression standardized residuals.

regression standard residual error of American GDP changes with multiple factors. According to the calculations (see Table 1), it can be seen that the average value is −4.58E−14 and the standard deviation is 0.775. The number of cases is 6. Through the residual diagram, we know that financial, trade, economic and financial governance, taxation, environmental protection, medical insurance, renewable energy power generation, and other countermeasures have greater impact on American GDP.

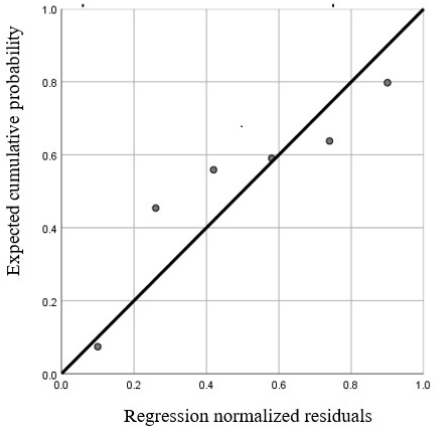

Figure 3. Grey prediction of expectation.

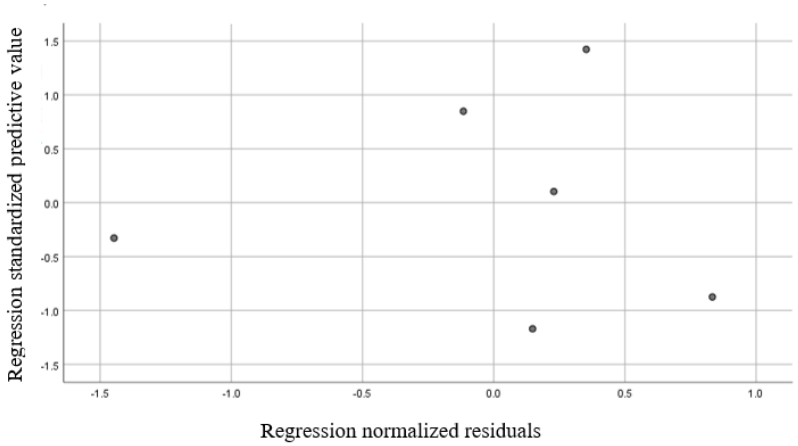

Figure 4. Grey prediction of actuality.

Table 1. Residual error sum.

	Min	Max	Average value	Standard deviation	Number of cases
Predictive value	17405.164062	21394.4023430	19206.35000	1537.96322	6
Residual	−134.2312622	77.282058715	−0.00000000042	71.8531313	6
Standard forecast	−1.171	1.423	0.000	1.000	6
Standard residual	−1.447	0.833	0.000	0.775	6

Figures 3 and 4 show that the expected probability of accumulation and the actual probability of accumulation for American GDP in the 15–20 period all have straight-line growth trend. Regression predictions make clear that all factors have some degree of influence to American GDP. The data may be adjusted as in Table 2, where (a) dependent variable is current price of American GDP, (b) for the predictive model, partial correlation (in short, PC) and collinear statistical tolerance (in short, CST) are severally given, (c) predictive variables in the model are (constant), USCE, TIFA, RLS, trade, ETVW, immigration, EUR, NIE, ECE, HE, PPHI and REPG.

From Table 2, it is easy to see that financial, trade, economic and financial governance, taxation, environmental protection, and medical insurance have greater impact to American GDP. According to the ratio of residuals and coefficients, the relevant factors can be obtained, which is more accurate for the solution of the models. Letting significance level $\alpha = 0.5$, then F-test can be performed on the required data as follows in Table 3, where predictive variables are FT, income, EP, PPHI, USCE, RES and ECE.

It is selected by F_{out} as in the Figure 3 and the significance of each factor is emerged. The conclusions obtained in this article have a relatively accurate explanation. Therefore, variable analysis with less significance will be conducted to improve the authenticity and practicability of the conclusions.

Table 2. Data analysis of impacting factors.

Variables in the model	Enter Beta	t	Significance	PC	CST
USCE	−0.032	−0.334	0.760	−0.190	0.423
TIFA	0.488	1.642	0.199	0.688	0.024
RLS	−0.050	−0.243	0.823	−0.139	0.093
Trade	−0.087	−1.449	0.243	−0.642	0.656
ETVW	0.111	3.521	0.039	0.897	0.794
Immigration	0.087	1.538	0.222	0.664	0.710
EUR	0.413	2.068	0.131	0.767	0.042
NIE	−0.283	−3.706	0.034	−0.906	0.124
ECE	−0.057	−0.516	0.641	−0.286	0.307
HE	−0.228	−2.239	0.111	−0.791	0.147
PPHI	−0.225	−3.222	0.049	−0.881	0.186
REPG	0.111	0.114	0.916	0.066	0.004

Table 3. Significance test.

Factor	FT	Income	EP	PPHI	CE	RES	ECE
F_{out}	0.76	0.56	0.50	0.62	0.65	0.54	0.62

4. Contrastive analysis based on SVMM

In the sequel, on the strength of work of Vapnik (Vapnik (1998)) and other pioneers, and analysis from the impact factors for American economy due to SRA and principle of SVMM, we use generalized linear classification of binary classification and select factors with greater influence.

Model 4.1. Step 1. *Input data and give goals according to the classification with respect to the impact factors reserved by SRA. That is, take N simple points,* $y = (y_1, y_2, \cdots, y_N)^T$, $X = (X_1, X_2, \cdots, X_N)^T$, X_j *is any point in our sample and* (X_j, y_j) *is the hyperplane sample classification for* $j = 1, 2, \cdots, N$. *Each sample of the input data contains multiple features and thus constitutes a feature space, and the target is a binary variable* $y_j \in \{-1, 1\}$ *for* $j = 1, 2, \cdots, N$, *which represents a negative class and a positive class.*

Step 2. *If there is a hyperplane as a decision boundary in the feature space, where the input data is located, the learning targets are separated into positive and negative classes, and the point-to-plane distance of any sample is greater than or equal to* 1. *That is,*

$$\begin{aligned} &\textit{Decision boundary:} \quad \omega^T X + b = 0 \\ &\textit{Point to plane distance:} \quad y_j\left(\omega^T X_j + b\right) \geq 1, \ \forall j = 1, 2, \cdots, N, \end{aligned} \tag{6}$$

where two parameters ω *and* b *are the normal vector and intercept of the hyperplane, respectively. It is called that the classification problem is linearly separable.*

Step 3. *Using the logarithmic barrier function of interior point method, optimization objective of approximating the SVMM problem is constrained in the following form:*

$$h(\omega, b) = -\sum_{j=1}^{N} a_j + \frac{1}{2}\sum_{j=1}^{N}\sum_{k=1}^{N}\left(a_j Q_{jk} a_k\right) + \sum_{i=j}^{N} I\left(-a_j\right) + \sum_{j=1}^{N} I\left(a_j - C\right) + b\sum_{j=1}^{N} a_j y_j, \tag{7}$$

here $\omega = (\omega_1, \omega_2, \cdots, \omega_N)$ *and* b *are Lagrange multipliers,* $Q_{jk} = y_j {X_j}^T X_k y_k$ *for* $j, k = 1, 2, \cdots, N$, $I(\lambda) = -\frac{1}{t}\log(-\lambda)$*, the logarithmic blocking function, is a continuous function of the multiplier* λ*, which is used to approximate the inequality relation in the constraint conditions in* (6)*,* t *is the parameter used to adjust the degree of approximation, and* C *is the constant going to infinity.*

By (7) *and applying Newton-Raphson method, we obtain the following hyperparameter:*

$$\hat{\omega} = \arg\min_{\omega} h(\omega, b), \tag{8}$$

which is compared in SVMM through low-rank approximation and parallel calculation.

Since some factors with little influence will be driven out when SRV is applied, based on model 4.1, we will discuss RLS, NIE, measures to combat COVID-19 in the United States, against US tax policy, analysis of American Health Care and obtain their relationship with the economic development of US.

(i) Analysis of the environmental and investment education measures in US.

Due to US' insistence on developing traditional energy and withdrawal from the Paris Climate Agreement, US' GDP has undergone significant changes (see Table 4) for variables: Revenue from landscaping service (in short, RELS) and net income from investment in education (in short, NIFEI).

Table 4. Data analysis of US' GDP.

	Model	RELS	NIFEI
Relevance	RELS	1.000	
Covariance	RELS	239.449	
Relevance	RELS	1.000	0.936
Relevance	NIFEI	0.936	1.000
Covariance	RELS	461.375	0.000
Covariance	NIFEI	0.000	3.087E-10

Substitute GDP as independent variable data into the SVMM (7), and replace the data in Table 4 into the formula for the economic growth of US, we have to compute the logarithmic blocking function $I(\lambda)$. Thus, it follows from (8) that one can get the hyperparameter $\hat{\omega}$.

(ii) Combatting measures against COVID-19 in US.

The United States announced its withdrawal from the World Health Organization and adopted a containment approach to COVID-19, resulting in a significant decline of the population in US. Substitute the unemployment rate in Table 5 as the independent variable data into (7), and replace the data here for the economic growth of US machine, and cover for the data here to the economic growth of US, we have to compute the logarithmic blocking function $I(\lambda)$. Then, Newton iterative method is to find the unemployment rate of the US' economic growth.

(iii) US tax policy

Table 5. Employment rate.

Time	2014	2015	2016	2017	2018	2019
Employment rate	6.20	5.30	4.90	4.40	3.90	3.70

It can be seen from Table 6 that the first measure and the second measure have different views on tax, and they hold opposite views. Hence, we collect and predict tax data listed in Table 7. And then, one

Table 6. Tax policy.

Democratic parties	Republican Party
Pc II	Pc I
Tax cuts burden the government	Support for tax cuts,

Table 7. GDP changes.

Revenue	GDP	GDP rate of increase
339.60	17418.90	2.45
329.10	17937.80	2.88
311.90	18566.90	1.57
245.40	19386.80	2.22
210.60	20500.60	2.93
217.30	21427.10	2.33

draws the conclusions: the change of US' GDP caused by tax cuts is substituted into the SVMM (7) as the independent variable, and the public for American economic growth is replaced with the data in Table 7, and the logarithmic blocking function is calculated via substituting the formula. Thus, Newton iterative method is used to find the unemployment rate on the economic growth of US.

(iv) Analysis of American medical insurance

Considering the lack of health care reform (in short, HCR) for Pc I, HCR of Pc II is deliberated as in Table 8.

From Table 8, it follows that there are three main contents of first, which are mandatory insurance for the applicant, insurance company's requirement of no refusal of insurance, and quality of medical institutions. The health insurance exchanges which are set up under HCR of Pc II, is the government organizations of collecting, organizing, and regulating insurance choices for individual consumers.

Second regards medical insurance as more commoditized, which removes its nature as a public good, reduces the government's financial expenditure on medical security, transfers this part of responsibility and risk to the market, and improves the economic efficiency of relevant industries.

In order to obtain more accurate data, we shall adopt a SVMM to predict data and obtain data comparison after respectively choosing by Pc I and Pc II. See Figure 5.

From Figure 6, one can see that in the next few years, if we take Pc I, then the GDP of US will continue to grow rapidly, but the growth rate will decline rapidly. The economy would have expanded when Pc II is adopted, but it is at a rising rate.

Table 8. Comparison of health insurance policies.

Variables	HCR of Pc I	HCR of Pc II
Compulsory insurance	Revenue Individual mandate: Companies with more than 50 employees force employers to insure their employees	Noncoercive: Use price levers to encourage participation
There are no guarantees or restrictions	No	One can refuse insurance and set limits
Price discrimination	Insurance companies can charge older people triple their premiums	Insurance companies can charge older people five times the premium and states can decide to remove the five times cap
Tax-free health account	$3,400 for individuals and $6,750 for families	$6,550 for individuals and $13,100 for families
Medical aid	Federal government finance assists all eligible people and extends eligibility to 138% of the poverty income line	Federal financial aid will be capped, and states will be required to tax those who receive it
Revenue	Medical investment income tax, high-income family tax, medical insurance corporation tax, medical devicecorporation tax	Exemptions for the four taxes mentioned on the left

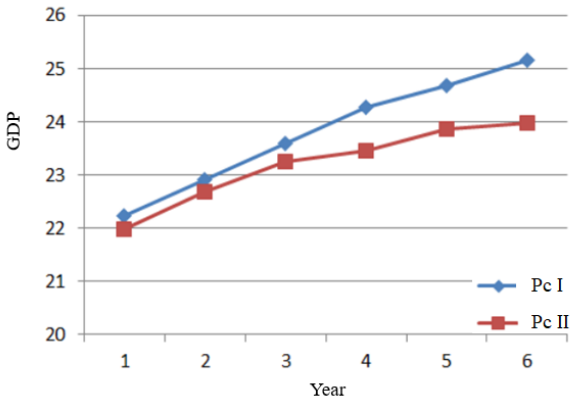

Figure 5. Prediction of GDP.

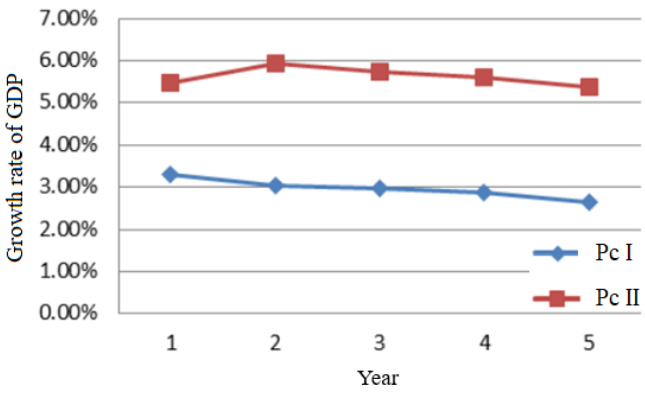

Figure 6. Prediction of change rate for GDP.

5. Conclusions

From SRA, one knows that finance and trade, economic and financial governance, taxation, environmental protection, and medical insurance have a great impact on American economy. In combining with uncertain factors, a thorough analysis is performed.

(i) If we take Pc I, then American economy will reach maximum development in the short term, even if the growth rate is down. However, when the uncertainties of the novel coronavirus and the unemployment rate in US were considered, it did not force people to wear masks in spite of his strengthened surrounding protection during the epidemic, which result in a large number of deaths and

a huge loss of economic and population unemployment. One can believe that the economy in US will grow as medical equipment reduces the outbreak.

(ii) Conversely, when Pc II is adopted, the economy will develop stable. It takes a long time before there is a clear pattern. the government of Pc II is likely to substantially increase taxes and take a strong position on financial regulation. This is still bad news for short term growth in US, but it remains uncertain whether Republicans will oppose policies in the Senate. If two opinions are combined and the second policies is adopted using the vector machine model, then American economy will be risen again, the new coronavirus can be contained to a certain extent, and the economic development and the safety of people are ensured. It would spend more on education, technology, roads and health care, the economy may be likely to grow slowly and will grow faster and faster.

Actually, we introduced SRA to remove and analyze the factors that have some impact on American economy, and apply SVMM to predict economic changes caused by Pc I and Pc II. The results presented in this paper provide a certain reference basis for analyzing the advantages and disadvantages of electing the government from Pc I and Pc II and the trend of American economy. However, the situation in US is changing, there are many factors to influence the American economic development and different trends. Encountering such situation, how to better study and analyze the impact of US policies on American economy? On the other hand, employing the goodness of fit test (chi-square value & p-value), ROC (AUC, sen, spe, etc.), calibration (C-index), mean square error, AIC, BIC, cross-validation (simple cross, K-fold cross-validation, N-fold cross-validation), bootstrap, cross-validation + bootstrap (currently the most commonly used) and so on (see Vapnik (1998); Mnich, et al. (2020); Sun, et al. (2021); Zhou (2021) and the references therein), how to perform some model evaluation and model validation for the SVMM presented in this paper? These are worth further study in the future.

Acknowledgments

This work was partially supported by the Sichuan Science and Technology Program (2019YJ0541).

We would like to express our thanks to the referees and editors for their valuable comments and helpful suggestions.

Conflict of interest

All authors declare no conflicts of interest in this paper.

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