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Forecast of China's economic recovery in the context of the COVID-19 pandemic

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Abstract: *The new crown pneumonia epidemic outbreak has had a severe impact on the economy and people's lives across China. Due to the mutation and contagious nature of the new crown pneumonia, economic recovery has been restricted. This article analyzes and predicts based on the data of eight provinces in China in the past six years (2015-2020), observes and discusses the degree of the economic impact of each province, and compares and analyzes the overall economic changes before, during, and after the epidemic. During the epidemic period, the eight provinces will be affected by the ten economic indicators. The eight provinces and China's economic recovery conditions will be put forward to achieve epidemic prevention and control. Implementation and recovery of economic development. In response to problem one of economic recovery forecasting, this article selects representative and relevant provinces from different regions of China for discussion. In order to avoid the concentration of selected provinces and the phenomenon of partial coverage, the Chinese regions are divided into Xinjiang and Qinghai from the northwest section, Sichuan and Yunnan from the southwest section, Hubei and Henan from the central China section, and from the northeast. Heilongjiang is selected for the lot, and Guangdong is selected from the South China lot. This article selects regional GDP, average real wage index, urban registered unemployment rate, and consumer price index as the consideration indicators. The four economic macro indicators are used to judge the goodness of fit through data fitting to establish a well-fitting correlation equation. Then, through the time series AR forecasting model, the forecast values of the four economic macro indicators for 2020 are calculated and compared with the actual values in the yearbook in 2020 to judge the overall economic changes in the middle of the epidemic. In addition, by comparing the year-on-year growth rate of economic development from January to March 2019-2021, the economic changes in the later epidemic period can be obtained. To obtain the degree of impact of the epidemic on each of the relevant economic indicators of the eight provinces, this paper uses the analytic hierarchy process to assign the degree of impact to the ten economic indicators to calculate the relevant weights, and conduct a consistency test by the consistency ratio. On this basis, this paper calculates the weighting influence of each province on each economic indicator, and then uses the total target weight as the basis for judging the severity of the impact of the new crown epidemic on each province, and compares and ranks it accordingly. Then, this article compares the weights of various economic indicators in each province to analyze the data results and find the objective reasons for the phenomena. In order to quantify the economic impact of each province, this paper uses the gray forecast GM (2,1) model to predict the economic error of GDP in 2021. Based on the first quarter of the GDP of each province in 2021, multiply it by 4 to get the theoretical annual GDP. Discuss the extent of the impact of the sporadic and small-scale outbreaks. Suppose the theoretical value is greater than the predicted value. In that case, it means that the province's epidemic prevention and control has been done properly, the economy has recovered significantly, and currency circulation has increased. If the theoretical value is less than the predicted value, it means that the province is greatly affected by the repeated outbreaks and economic recovery is restricted. Regarding the economic impact of the entire country, we use GDP as a test indicator to predict the national GDP in 2021 through the gray forecast GM (2,1) model from GDP in 15-20 years. In the same way, based on the first and second quarters of 2021, the theoretical national GDP of 2021 is obtained by adding and multiplying by two, and comparing the GDP year-on-year growth rate with the predicted growth rate, the development trend and sporadic exposure to the epidemic can be obtained. The magnitude of the impact that occurred. Finally, this paper carries out error analysis and consistency check on the established model, and at the same time evaluates the advantages and disadvantages of the model.*

Keywords: *AR forecasting model, analytic hierarchy process, fitting equation, grey forecasting model, economic development*

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1. Introduction

At the end of 2019, the COVID-19 pandemic broke out in Wuhan, China, and quickly spread worldwide. Not only does it harm people's lives and health, it also puts tremendous pressure on our country's economic and social development from all aspects. In the face of the sudden epidemic, the Chinese government has also adopted strong controls to control the epidemic as soon as possible. On the premise of safeguarding the health of the people, my country has begun to resume work and production in an orderly manner, with precise policies on different industries, and the economy is gradually recovering. Due to the differences in the economic status, internal characteristics, and external policies of different industries, the extent to which different industries are affected by the epidemic also reflects certain characteristics. Try to establish a mathematical model to analyze and study the following issues regarding the impact of the pandemic on all aspects of the economy:

(1) According to the degree of the pandemic outbreak and the degree of control by the authorities, the three stages of pre-pandemic, mid-pandemic, and post-pandemic are distinguished and the overall economic changes are analyzed.

(2) Select ten macro and industrial indicators to study the overall changes in the economy and analyze the impact of the pandemic on different provinces and industries.

(3) As my country enters the post-pandemic period, the society has resumed work and production, but there are still a few sporadic outbreaks of pandemics—analysis of its impact on the economy of various provinces and the entire country.

(4) Finally, put forward practical, reasonable, and effective policies for the authorities and governments in the later stages of the pandemic.

2. Model assumptions

(1) Assuming that all the data obtained are true and accurate

(2) Assuming that other variables that affect the results of the analysis are negligible relative to the epidemic

(3) Assuming that the weights assigned to relevant economic indicators in the analytic hierarchy process are objective and reasonable

(4) Assuming that the data processed by the AR model meets the conditions of stable data

(5) Assuming that the collected data does not necessarily appear as a clear statistical regression correlation, but with internal connections, which is suitable for gray forecasting models

(6) Assuming that the GDP of the country in 2021 is the sum of the GDP of the previous two quarters multiplied by 2

(7) Assuming that the GDP of each region in 2021 is the total value of the previous quarter multiplied by 4

3. Symbol description

Symbol	Description	Unit
p_i, $i=1,2,3,4,5$	Corresponding to the coefficients in the fitting equation	
$C1$	gross regional domestic product	100 million yuan
$C2$	index of average real wages	100
$C3$	urban registered unemployment rate	%
$C4$	consumer price index	%
$C5$	agricultural means of production price index	100
$C6$	labor productivity as measured by the total output value of construction industry	%
$C7$	total retail sales of consumer goods	100 million yuan
$C8$	imports and export value of goods	100 million yuan
$C9$	consumer price index for tourism	Million dollars

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$C10$	total liability	100 million yuan
$Ck\text{-}E, k=1, \cdots, 10$	The severity of the impact on an indicator among eight provinces	
$x^{(0)}$	A sequence is generated by a single summation	

4. Model construction and solution

4.1. Model establishment and solution

4.1.1. Changes from before the epidemic to the epidemic

Taking Henan Province as an example, according to the regional production indicators from 2015 to 2019, polynomial fitting is used to construct a fitting equation:

$$f(x) = p_1 * x^4 + p_2 * x^3 + p_3 * x^2 + p_4 * x + p_5 \quad (1)$$

Use the CurveFittingTool toolbox of Matlab to get the coefficients of the fitting function equation:

$$p_1 = 1844 \quad p_2 = 688.1 \quad p_3 = -2548 \quad p_4 = 5720 \quad p_5 = 44990$$

Therefore, the fitting equation is:

$$f(x) = 1844 * x^4 + 688.1 * x^3 - 2548 * x^2 + 5720 * x + 44990 \quad (2)$$

The goodness of fit of this equation is 1.00, which indicates a complete fit, and the sum of squared errors SSE is 6.882e-22, which is extremely close to zero. It can be concluded that the fitting effect of the fitting equation is good.

Using the fitting equation (2), calculate the GDP of Henan Province in 2020, and calculate the relative error by calculating the difference between the predicted value and the actual value, as shown in Table 1.

Table 1: Summary of forecast value, actual value and relative error of GDP in Henan Province

Year	2015	2016	2017	2018	2019	2020
Forecast GDP of Henan Province (100 million yuan)	37002	40472	44988	48056	54259	55234
Actual GDP of Henan Province (100 million yuan)	37002.16	40471.79	44988.16	48055.86	54259.20	54997.07
The relative error	0.16	-0.21	0.16	-0.14	0.20	-236.93

Analyzing the table data shows that the relative error from 2015 to 2019 is basically less than 0.2, and the fit is good. In 2020, the predicted GDP of Henan Province is 5,523.4 billion yuan, while the actual value is 5,499.707 billion yuan, with a relative error of -23.693 billion yuan. It reflects that under the impact of the epidemic, the production level and social and economic development of various industries in Henan Province have been severely affected.

Refer to the above method to calculate the 2020 forecast value and relative error of the GDP of the eight provinces and regions, as shown in Table 2:

Table 2: The forecast value, actual value and relative error of GDP of eight provinces in 2020

	2020 forecast value	2020 actual value	The relative error	Relative error percentage
Heilongjiang	8700	13698.50	4998.50	57.45%
Henan	55234	54997.07	-236.93	-0.43%
Hubei	43951	43443.46	-507.54	-1.15%
Guangdong	112870	110760.94	-2109.06	-1.87%
Sichuan	51081	48598.76	-2482.24	-4.86%
Yunnan	25896	24521.90	-1374.10	-5.31%
Qinghai	3284.2	3005.92	-278.28	-8.47%
Xinjiang	15112	13797.58	-1314.42	-8.70%

In Table 2, in addition to the abnormal value of Heilongjiang Province, the actual value of the GDP of each province is lower than the predicted value, reflecting the negative impact of the epidemic impact on the regional GDP.

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In the same way, calculate the predicted values and relative errors of the average real wage index, urban registered unemployment rate, and consumer price index in eight provinces in 2020, as shown in Table 3, Table 4, and Table 5:

Table 3: The forecast value, actual value and relative error of average real wage index of eight provinces in 2020

	2020 forecast value	2020 actual value	The relative error	Relative error percentage
Heilongjiang	108.15	106.5	-1.65	-1.55%
Henan	106.36	102.1	-4.26	-4.17%
Hubei	110.43	104.8	-5.63	-5.37%
Guangdong	109.49	106.8	-2.69	-2.52%
Sichuan	104.54	103.8	-0.74	-0.71%
Yunnan	106.81	105.1	-1.71	-1.63%
Qinghai	113.45	109	-4.45	-4.08%
Xinjiang	109.72	106.3	-3.42	-3.22%

In Table 3, the actual average wage index in each province is lower than the predicted value. Due to the suspension of work and production under the epidemic, the society has stopped functioning, which has greatly reduced the average wage level of residents. The absolute value of the relative error percentage reflects the severity of the impact of the epidemic to a certain extent. Among them, Hubei Province, where the epidemic is the worst, has the largest absolute value of the relevant error percentage, reflecting the suspension of various industries under the influence of the epidemic, the reduction of wage levels, and the severe impact on the economy.

Table 4: Prediction, actual and relative errors of urban registered unemployment rate in eight provinces in 2020

	2020 forecast value	2020 actual value	The relative error	Relative error percentage
Heilongjiang	3.16	3.37	0.21	6.23%
Henan	3.1	3.24	0.14	4.32%
Hubei	2.72	3.35	0.63	18.81%
Guangdong	2.31	2.53	0.22	8.70%
Sichuan	3.52	3.63	0.11	3.03%
Yunnan	3.69	3.92	0.23	5.87%
Qinghai	2.19	2.13	-0.06	-2.82%
Xinjiang	2.24	2.39	0.15	6.28%

In Table 4, with the exception of Qinghai Province, the actual values of registered urban unemployment rates in all provinces are higher than the predicted values, reflecting that the epidemic has increased the unemployment rate of residents and affected the socio-economic conditions. In view of the pressure on corporate cash flow under the epidemic situation, and due to potential health threats, companies have laid off employees one after another, leading to an increase in the unemployment rate. The relative error percentage in Hubei Province is as high as 18.81%, the actual unemployment rate is much higher than expected, and it is most affected by the epidemic.

Table 5: Forecast value, actual value and relative error of consumer price index of eight provinces in 2020 (last year =100)

	2020 forecast value	2020 actual value	The relative error	Relative error percentage
Heilongjiang	101.42	102.3	0.88	0.86%
Henan	100.76	102.8	2.04	1.98%
Hubei	99.83	102.7	2.87	2.79%
Guangdong	100.47	102.6	2.13	2.08%
Sichuan	102.34	103.2	0.86	0.83%
Yunnan	102.55	103.6	1.05	1.01%
Qinghai	100.79	102.6	1.81	1.76%
Xinjiang	100.41	101.5	1.09	1.07%

In Table 5, with the exception of Xinjiang, the actual consumer price index was higher than expected. During the epidemic period, production was restricted, transportation was difficult, and materials were

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in short supply. The supply of goods and services decreased, and the supply exceeded demand, and prices rose. From the data point of view, the relative error percentage in Hubei Province is as high as 2.79%, and prices have risen significantly; due to national policy support, fluctuations in other provinces are still within acceptable limits, and residents' living consumption will be slightly affected.

4.1.2. Economic changes during and after the epidemic

Through the comparison of the growth rates over the same period in the past three years, it can be found that due to the severe impact of the new crown pneumonia epidemic, the growth rate of the provinces in the first quarter of 2020 has declined, of which the growth rate of Hubei Province in the first quarter of 2020 has dropped sharply, from 108.1% It dropped to 60.8%, showing unprecedented negative growth in recent years. From the full outbreak of the epidemic in early February and the closure of the Lihan Channel to the initial effective control of the outbreak in April, Wuhan lifted traffic control. This quarter, especially in areas with severe epidemics, social production has stagnated, and there is only a small amount of necessary social security. The sex industry continues to operate. As the epidemic broke out, Hubei was the first to be severely affected, with the most significant decline in regional GDP. Because Xinjiang is located in an inland region, its industries are relatively less dependent on other provinces. The decline in regional GDP is the smallest among the eight provinces.

Comparing the data of 2020 and 2021, it is found that in the first quarter of 2021, the GDP of various provinces and regions rebounded rapidly, with a year-on-year growth rate of more than 112%. Due to the repeated epidemics in Heilongjiang, economic recovery is limited. The GDP of the remaining provinces and regions has all recovered to above the level of the same period in 2019. After the epidemic was controlled, the Chinese government implemented specific policies to gradually and orderly promote the resumption of work and production to ensure the health of the people. The various links of production, distribution, exchange and consumption gradually recovered, the overall social economy was restored, and the GDP increased. . Among them, Hubei Province has the fastest growth rate, with a year-on-year growth rate of 158.3% in GDP. Suppose the data of the same period of 2021 and 2019 are compared to eliminate the influence of the particular period on the growth rate calculation. In that case, the growth rate of regional GDP is 108.37%, which exceeds. The same period in 2019 reflects the solid economic recovery flexibility and effective implementation of policies.

Table 6: Statistical table of GDP and year-on-year growth rate of provinces in the first quarter of the past three years

	2019.1~3		2020.1~3		2021.1~3	
	Regional GDP (100 million yuan)	Year-on-year growth rate (%)	Regional GDP (100 million yuan)	Year-on-year growth rate (%)	Regional GDP (100 million yuan)	Year-on-year growth rate (%)
Heilongjiang	3184.57	105.3	2409.04	91.7	2692.47	112.4
Henan	11639.05	107.9	11510.15	93.3	13306.65	115.4
Hubei	9110.05	108.1	6379.35	60.8	9872.67	158.3
Guangdong	23886.77	106.6	22518.67	93.3	27117.96	118.6
Sichuan	9653.18	107.8	10172.85	97	11859.24	115.8
Yunnan	3849.65	109.7	5107.77	95.7	5958.64	115.3
Qinghai	557.09	105.7	652.68	97.9	743.88	112.8
Xinjiang	2177.69	105.3	3055.51	99.8	3402.54	112.1

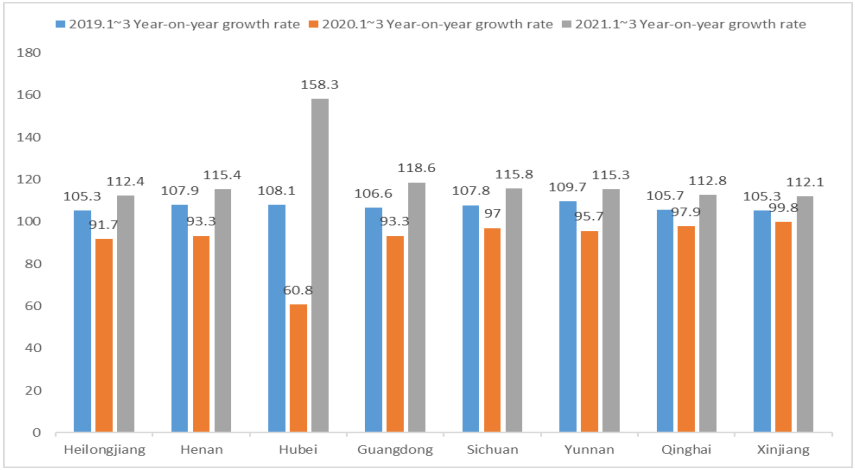

Figure 1: Year-on-year growth rates of GDP of provinces in the first quarter of the past three years

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4.2. Establishment and solution of hierarchical model

4.2.1. Establish a hierarchical structure model

The analytic hierarchy process is a decision analysis method that combines qualitative and quantitative analysis to solve complex problems with multiple goals. This method combines quantitative analysis with qualitative analysis, and uses the experience of decision-makers to judge whether each goal can be achieved. The relative importance of each decision plan is given, and the weight of each criterion of each decision-making plan is given reasonably. The weight is used to find the order of superiority and inferiority of each plan. The analytic hierarchy process is an effective tool in the decision-making of the social economic system. Its characteristics are reasonable. It combines qualitative and quantitative decision-making, and hierarchizes the decision-making process according to the laws of thinking and psychology. Quantitative is a commonly used system in system science. Analytical method.

According to the requirements of the scenario, the following hierarchical structure was developed:

The highest level: the extent of the impact of the epidemic

Middle level: ten economic indicators

The lowest level: eight provinces

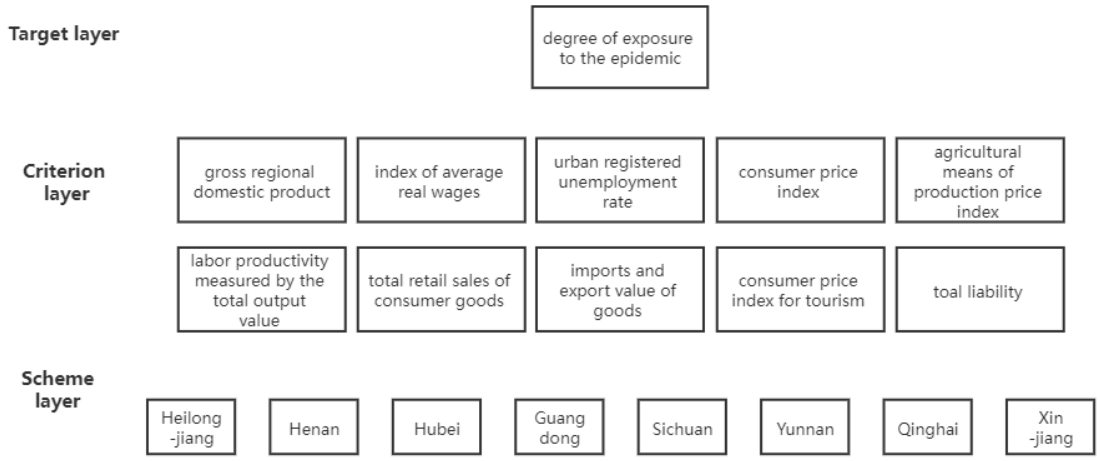

Figure 2: Relationship diagram of target layer, criterion layer and scheme layer

4.2.2. Results

The overall degree of impact by the epidemic: Hubei> Heilongjiang> Xinjiang> Qinghai> Guangdong> Yunnan> Henan> Sichuan.

Table 7: Ranking of different economic indicators affected by the epidemic in different provinces

economic indicators	Affected by the epidemic (sorted by weight)							
Province	Heilongjiang	Henan	Hubei	Guangdong	Sichuan	Yunnan	Qinghai	Xinjiang
gross regional domestic product	2	5	1	6	7	8	3	3
index of average real wages	2	5	5	3	4	1	5	5
urban registered unemployment rate	7	4	1	3	6	2	8	5
consumer price index	3	4	4	1	6	7	6	1
agricultural means of production price index	7	4	6	5	8	2	1	2
labor productivity as measured by the total output value of construction industry	1	6	7	2	4	8	5	3
total retail sales of consumer goods	2	6	1	5	8	7	3	3
imports and export value of goods	2	6	5	4	8	7	1	3
consumer price index for tourism	8	5	2	7	5	1	3	3
total liability	3	3	8	7	5	6	2	1

4.3. Establishment and solution of GM model

Since economic changes meet the exponential growth and are not a monotonous process, this time

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the gray forecast model GM (2,1) is used to predict the GDP of the eight target provinces in 2021, so as to compare with the country. The statistics on the official website of the Bureau of Statistics are compared to determine the degree of economic impact of various provinces in the context of repeated epidemics.

Take Heilongjiang Province's gross domestic product (GDP) from 2015 to 2020 as a column, construct a GM (2,1) model:

GM(2,1) time response: x=7714277-41.5826*e^0.742786t-7699144.0*e^-0.00200826t

So as to obtain relevant data results

Table 8: Results of grey prediction model in Heilongjiang Province

The actual value	15083.67	15386.09	16199.88	16361.62	13612.68	13698.50
Predictive value	15084.00	15401.00	15182.00	15182.00	14928.00	14429.00
Residual	0.30	14.90	880.90	1179.60	-1315.30	-730.50
The relative error	0.00	0.00	0.05	0.07	0.10	0.05
Accumulated value	15084.00	30484.00	45803.00	60985.00	75914.00	90342.00

According to the above solution mode, we can get:

Table 9: Time response formula of grey prediction model in each province

Time response of Heilongjiang Province	X_1=7714277-41.5826*e^0.742786t-7699144.0*e^-0.00200826t
Time response of Henan Province	X_2=433983.0*e^0.0896976t-3.87153*e^1.31968t-396977.0
Time response of Hubei Province	X_3=312338.0*e^0.0999966*-9.13618*e^1.25257*t-282778.0
Time response of Guangdong Province	X_4=800262.0*e^0.0964842t-83.3894*e^0.953222t-727366.0
Time response of Sichuan Province	X_5=294740.0*e^0.107009t-3.11154*e^1.35558t-264684
Time response of Yunnan Province	X_6=101131.0*e^0.136573t-1.69238*e^1.4263t-87510.1
Time response of Qinghai Province	X_7=49437.6*e^0.0503598t-0.364519*e^1.13033t-47020.2
Time response of Xinjiang Province	X_8=96188.6*e^0.0989806t-3.63854*e^1.19524t-86860.2

According to the above time response formula, the total GDP of the province in 15-21 years can be obtained

Table 10: Total GDP of each province calculated by grey forecasting model

Province	Heilongjiang	Henan	Hubei	Guangdong	Sichuan	Yunnan	Qinghai	Xinjiang
2015-2021 GDP	103766.68	338087.24	269820.34	705431.39	285198.44	133557.10	19392.77	83677.32
2015-2020 GDP	90342.00	279700.00	227380.00	559260.00	235860.00	110570.00	16469.00	69488.00
2021 predicated GDP	13424.68	57387.24	42440.34	146171.39	49338.44	22987.10	2923.77	14189.32
2021 Total theoretical GDP	10769.88	53226.60	39490.68	108471.84	47436.96	23834.56	2975.52	13610.16
Ratio	1.2465	1.0781	1.0746	1.3475	1.0401	0.9644	0.9826	1.0425
Rank of the degree of impact	2	3	4	1	6	8	7	5

The greater the proportion, the greater the degree of impact, that is, due to the sporadic occurrence of the epidemic, the theoretical value has not reached the predicted value. If the ratio is less than 1, it indicates that the probability and impact of the repeated occurrence of the epidemic is relatively small, and the economy will recover quickly.

4.4. Analysis of results

The outbreak and spread of the epidemic will significantly impact the order of social production and life and the macroeconomic situation in the short term. It will move the macroeconomy from the supply and demand sides simultaneously and affect the meso-level industries and micro entities. The short-term impact of the epidemic will be tremendous. But it will not change the trend of China's economy in the medium and long term. In the long run, the government may use this as an opportunity to vigorously promote reforms, improve national governance, and at the same time, give birth to new business models. In addition, the epidemic has exposed shortcomings in early information disclosure, media supervision, emergency medical care, people's livelihood expenditure, and social governance system, which need to be strengthened urgently.

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4.4.1. Specific impact

(1) Impact on the micro-level: During the epidemic, different micro individuals have different levels of impact. According to the magnitude of the impact, private enterprises are greater than state-owned enterprises and small, and micro-enterprises are greater than large enterprises. Special attention should be paid to the employees with the flexible salary system, whose basic guarantee is low and their income fluctuates wildly. They are the people most affected by the epidemic. Small, medium and micro enterprises have created the most jobs and have made significant contributions to increasing residents' income and maintaining social stability. The flexible salary system has many employees, but the social security and anti-risk capabilities are feeble. In recent years, economic growth has declined, business efficiency has decreased, and employment pressure has increased. Superimposed on the impact of this epidemic, vulnerable groups such as small, medium, and micro enterprises and employees with flexible salary systems need to focus on and support.

(2) Impact on national governance: Government governance will be more transparent, production and living formats will develop toward intelligence and online, and opportunities will be brewing in risks. Big data is vital to the monitoring of population flow destinations and residence time and is directly related to the prevention and control of the source of infection. This will stimulate the openness and transparency of government governance in the future and improve coordination and organization capabilities.

4.4.2. Suggested government measures

(1) Short-term measures

1) Fiscal policy is the key, increasing tax cuts and expenditures.

a) Increase support for small and micro enterprises, implement the 30 loan support measures issued by the Central Bank and the Ministry of Finance for small and micro enterprises in epidemic areas and severely affected industries and introduce tax reduction and exemption policies.

b) Appropriate value-added tax reduction or exemption for sectors severely affected by the epidemic in the first quarter, especially transportation (civil aviation, road passenger transportation, waterway passenger transportation, and taxi), tourism, catering, accommodation, and other industries. The amount of loss is offset by the amount of profit in the month. Reduce the income tax base.

c) To further reduce the social security payment rate, the pension and medical payment rates can be reduced by 1 and 2 percentage points, respectively, reducing the burden on enterprises.

d) Appropriate financial subsidies and interest discounts will be given to enterprises and industries that have suffered losses due to the epidemic's impact, and there is no need to set up list management to expand the scope of benefits.

e) Expand the deficit rate to 3%. The current fiscal revenue and expenditure contradictions are enormous, fiscal revenue is declining, and epidemic prevention and control expenditures are increasing. These are unexpected expenditures. To avoid squeezing other people's livelihoods and stabilize growth expenditures, it is necessary to expand the deficit.

2) Targeted interest rate cuts and RRR cuts for the hardest-hit regions and industries. In addition to providing short-term liquidity, targeted interest rate cuts in the hard-hit areas and enterprises will stabilize market expectations and help companies tide over difficulties.

(2) Long-term reform measures: reform of the deep-level system and mechanism issues

1) Strengthen the social governance system and local government governance capacity building.

2) It is to improve the governance body, promote the government, society, and the public to participate in consultations, and strengthen cooperation at the level of information sharing and information reporting.

3) Mobilize the enthusiasm of local governments and entrepreneurs, give local officials a new incentive mechanism, and provide peace of mind to private entrepreneurs.

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