Team Control Number

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Problem Chosen

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ShuWei Cup

Summary Sheet

Summary

In this paper, through the establishment of material scheduling and distribution model, design the optimal basic living security plan for residents, according to different epidemic levels, establish regression model, formulate reasonable production resumption plan. From the perspective of government management, establish capacity satisfaction rate model, formulate a long-term national development strategy related to the interests of all parties. In order to ensure stable economic development, maximize the control of the epidemic. In order to control the epidemic situation, we should establish a statistical model and formulate control strategies for public transport and catering under different epidemic levels.

For the first problem, when the epidemic situation is serious, how to ensure the basic life of residents in a certain city, that is, how to allocate the limited basic medical and living materials to the places where they need them in a certain period of time. Therefore, we designed the scheduling and distribution model of medical and living materials necessary for residents when the epidemic situation is serious. The emergency index of demand point is constructed from the two dimensions of medical and living materials use demand and inventory estimation available time. Considering the event characteristics of severe epidemic, the main objective is to maximize the weighted demand satisfaction rate and minimize the vehicle driving distance mixed integer nonlinear multi-objective programming model is established, and the effectiveness and feasibility of the model are verified by a numerical example. The optimal basic living security plan of a city is found out when the epidemic situation is serious.

For the second problem, we focus on the catering industry in the service industry, under different epidemic levels of production plan. By selecting the optimal regression algorithm model Bayesian regression model, the loss of the growth rate of the added value of the tertiary industry in China in 2020 is calculated. According to the resumption rate of the catering industry and the recovery rate of production and sales during the latest epidemic, the loss prediction value of the growth rate of the added value of the tertiary industry is converted into the loss of the added value of the catering industry, and the added value of the catering industry accounts for the main business income In order to calculate the dynamic loss of the operating income of the catering industry, and to formulate a reasonable production resumption plan.

In view of the third problem, the government formulates the national development strategy, selects a part of the large number of application enterprises to approve the resumption of work and production, and arranges the resumption time within the specified decision-making period, so as to maximize the comprehensive capacity demand satisfaction rate of all related industries under the constraints of epidemic spread risk, establishes a nonlinear integer programming model, and solves the model by greedy algorithm, The accuracy of the model is verified by the data of resumption of work and production in three places.

In view of the fourth problem, the paper provides control strategies for crowded industries such as bus catering, so as to promote economic development under the premise of controlling the spread of the epidemic. Therefore, the canonical correlation analysis method is used to study the correlation between control strategy, epidemic level and local economic development level. The maximum correlation coefficient of the two groups of variables is taken as the goal, and the intermediate variable (m) is defined to introduce the intermediary effect, and finally the correlation between the two groups of variables is obtained, which effectively reveals the linear dependence between the two groups of variables, and develops appropriate control strategies

Key word: **Mixed Integer Nonlinear Multi-Objective Programming Model, Nonlinear Integer Programming Model, Greedy Algorithm , Bayesian Ridge Regression, Mediating Effect, Canonical Correlation**

Contents

1 Introduction

1.1 Background

COVID-19, widely spread all over the world, has seriously affected the economic development of many countries. China is no exception. Though it has effectively controlled the large-scale spread of the epidemic, many industries have still been affected at different levels. While the epidemic has brought depression to some companies, it has also provided vitality to others. Typical cases include the rapid rise of some medical companies and the closure of some large-scale chain hotels.

Recently, the epidemic has rebounded in many places around the world, and new locally-confirmed cases have also appeared in many cities in China. There are many reasons for the further spread of the epidemic, among which the most common are resuming work, going to parties and shopping. Therefore, we need to establish a mathematical model to formulate reasonable COVID-19 prevention strategies to get out of the epidemic as soon as possible.

1.2 Restatement of the Problem

(1) We need to provide a basic living supplies guarantee plan for residents in a certain city under the severe situation of the epidemic.

(2) We need to provide the resumption plan of work and production for a certain type of enterprise under different epidemic levels, in which the spread of the epidemic and the dynamic change of product demand should be fully considered.

(3) From the perspective of government management, we need to formulate a long-term national development strategy under the epidemic that weighs the interests of all parties.

(4) We need to provide management and control strategies for the public transportation and catering industry under different epidemic levels, so as to ensure the stable economic development and control the spread of the epidemic to the maximum extent.

2 Problem analysis

2.1 Analysis of question one

For the first problem, it is required to provide the basic living security plan for the residents when the epidemic situation is serious, and establish a scientific material distribution model based on the dynamic changes of the supply and demand of living and emergency living materials. Therefore, we analyzed and combined with the existing distribution model to measure the fairness of the optimization goal (demand satisfaction rate), and based on the actual situation of the deployment of living and medical materials in the new epidemic prevention and control, the main objective was to maximize the weighted demand satisfaction rate, and the principle of nearby transportation was the secondary objective, and the dynamic distribution of urban emergency living materials was constructed when the epidemic situation was serious Model.

In addition, in view of the material mobilization within a city territory, combined with the experience of the new epidemic prevention and control, we gave up the three-level emergency material distribution network of regional material dispatching, and chose a more appropriate two-level material distribution network of "centralized distribution center demand point". The ratio of the materials obtained by the demand point to its demand quantity is the most critical index to characterize the fairness and rationality of the limited material allocation. Therefore, the main idea of our modeling is to maximize the sum of the satisfaction rates of all demand points, and to solve the problem that the demand points with small demand can be satisfied first, the existing model is modified by increasing the demand urgency correction coefficient.

Finally, python crawler is used to crawl the number of people using and inventory of materials at the demand point during the epidemic period. In addition, in order to solve some data missing, automatic calculation method is adopted to meet the requirements of material distribution for urban life and emergency living, which can take into account the fairness and efficiency of material distribution, further realize the precise matching of supply and demand, and reasonably allocate the limited resources.

2.2 Analysis of question two

For the second problem, the epidemic situation will have a huge impact on service-oriented enterprises in China in the short and medium term, and we select the typical catering industry for modeling analysis. However, it is difficult to obtain the relatively new authoritative economic data related to China's catering enterprises. Therefore, in order to ensure the reliability and effectiveness of the data, this paper will mainly assess the impact of the epidemic on China's catering enterprises through the proportion of catering industry in the tertiary industry.

According to the main factors affecting the development of the tertiary industry in China, the explanatory variables are constructed, and then the Bayesian ridge regression multiple regression model is constructed. The following indicators are selected for model test: interpretable variance, average absolute error, mean square deviation, determination coefficient, and the effect of actual value and predicted value is evaluated. Finally, according to the optimal production prediction model, combined with different epidemic severity levels, the appropriate scope of resumption of production was determined to determine the final resumption production plan of the catering industry.

2.3 Analysis of question three

The third problem is that the government formulates the national development strategy, selects some enterprises from a large number of applicants to approve the resumption of work and production, and arranges the time for resumption of work and production within the specified decision-making cycle. Under the constraints of not violating the epidemic transmission risk, the government maximizes the comprehensive capacity demand of all related industries, establishes and solves the planning model, and verifies the accuracy of the model with the actual data.

2.4 Analysis of question four

For cities with different epidemic levels, the profit development status of the public transport catering industry, that is, the areas with dense passenger flow, is affected by the intensity and timeliness of management and control. Therefore, we used canonical correlation analysis to study the correlation between control strategy, epidemic level and local economic development level, and converted it into the correlation between two groups of typical variables. Taking the maximum correlation coefficient of two groups of variables as the goal, we conducted the self correlation test, the moderating effect of control intensity in the impact of control timeliness on urban economic conditions, and the timeliness of management and control in the city Finally, different control strategies were adopted according to different epidemic situation.

3 Symbol and Assumptions

3.1 Symbol Description

Symbol	Description
I	Collection of emergency living materials distribution center， $i \in I$
J	Collection of demand points for emergency living materials， $j \in J$
N	Collection of emergency living materials， $n \in N$
r_{ij}	Vehicle travel distance from distribution center I to demand point J
D_{ij}^{k}	The demand of demand point J for living materials n in the K period
Q_{ij}^{k}	Inventory of living materials n in the centralized distribution center I at the beginning of period K
$r_{\max}$	Upper limit of transportation distance

Symbol	Description
M	Upper limit of the number of centralized distribution centers transporting medical materials from centralized distribution center I to demand point J
p_{ij}	The number of users of living material n at demand point J in period K
Q_{jn}^{k}	Inventory quantity of demand point J living materials n at the beginning of period K
s_{n}^{k}	Consumption rate of daily necessities n in the K period
t_{jn}^{k}	Estimated usable time of inventory for demand point J and living materials n in period K
T^{k}	Duration of period K, in days
ω_{jn}^{k}	The urgency of the demand point J to the demand of living materials n in the K period
GRAVTI	Growth rate of added value of tertiary industry
ZXQCZ	Added value of catering industry
ZXYS	Business income of catering owners
QFGR	Resumption rate of catering industry
CXHR	Recovery rate of production and sales in catering industry

3.2 Fundamental assumptions

In order to facilitate the distribution of basic materials in a certain city, the following assumptions are made for the actual situation of the epidemic situation:

[1] The material supply of the centralized distribution center is known in the material distribution, and each demand location timely reports the inventory of living materials and the number of users;

[2] The demand point with high demand urgency has priority to obtain materials, and different types of materials can be mixed and transported, and there is no substitute effect for each other;

[3] Considering the efficiency of material transportation and transfer, the existing centralized distribution center can be used as the material transfer, or the material supply point can be directly used as the temporary centralized distribution center, so as to solve the urgent problem of scarce materials. However, the location of the centralized distribution center should be determined before the material distribution

[4] Material transportation related issues are not considered. For example, material transport vehicles, transport mode, transport capacity constraints and other related issues.

[5] Take the city's economic situation as an approximate substitute for the stable development of the public transportation and catering industry.

4 Analysis and Modeling

4.1 Model establishment and solution of problem one

The optimization objectives of the existing emergency material allocation models can be divided into three categories

1. Considering the fairness of distribution, the goal is to maximize the demand satisfaction rate;
2. Considering the efficiency of rescue, the shortest time is the goal;
3. Considering the economy of scheduling, the objective is to minimize the cost.

As novel coronavirus and other major public health emergencies, the cost of emergency rescue and basic living guarantee is incomparable to the loss of the whole society and economy. Therefore, the cost problem is ignored.

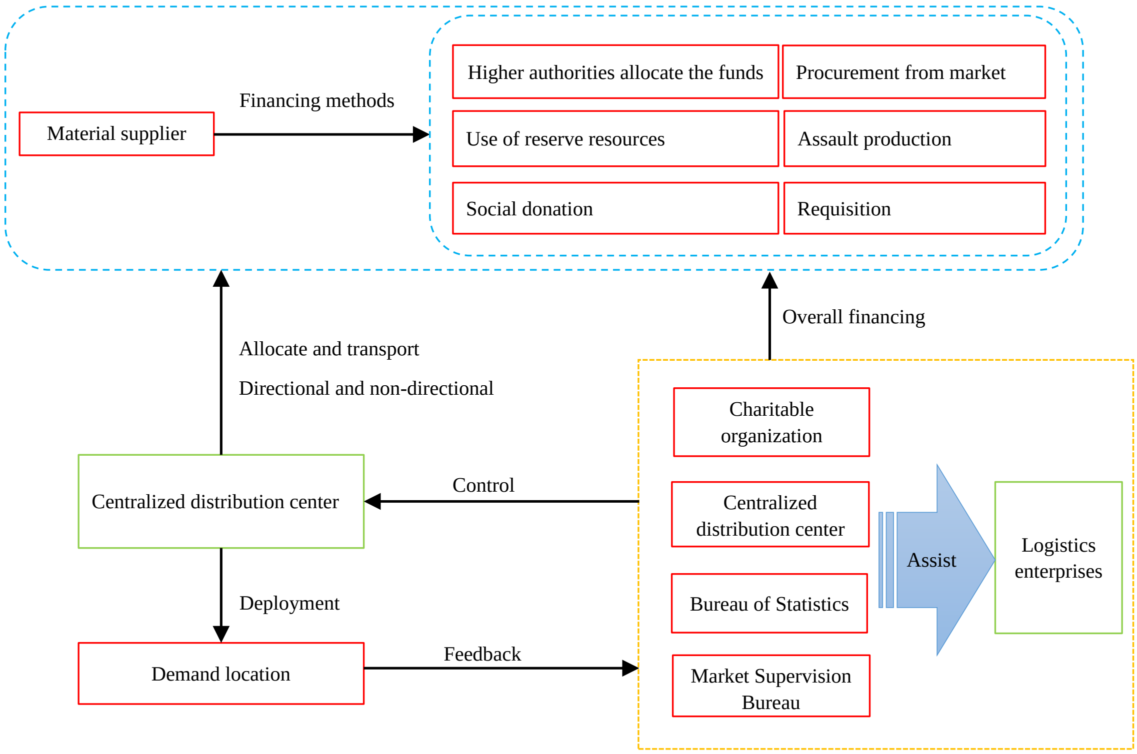


Figure 4-1 Dispatching and distribution system of emergency medical materials

Based on the above analysis, the goal is to minimize the travel time of transportation vehicles from the centralized distribution center to the demand point. Considering the characteristics of public health emergencies, driving distance was used instead of travel time. Taking the minimum total driving distance as the secondary objective, that is, on the premise of the maximum demand satisfaction rate, the principle of nearest transportation shall be adopted as far as possible.

We define the demand satisfaction rate = the material / demand quantity obtained by the demand location, and the problem with this goal is that the demand points with small demand can be satisfied preferentially. Therefore, a modified model of demand urgency correction coefficient is added. Considering the disaster severity and material demand characteristics, the availability of data, and avoiding subjective evaluation as far as possible, the objective data is used for analysis, and then the evaluation is conducted from two dimensions of the number of victims and the available time of materials.

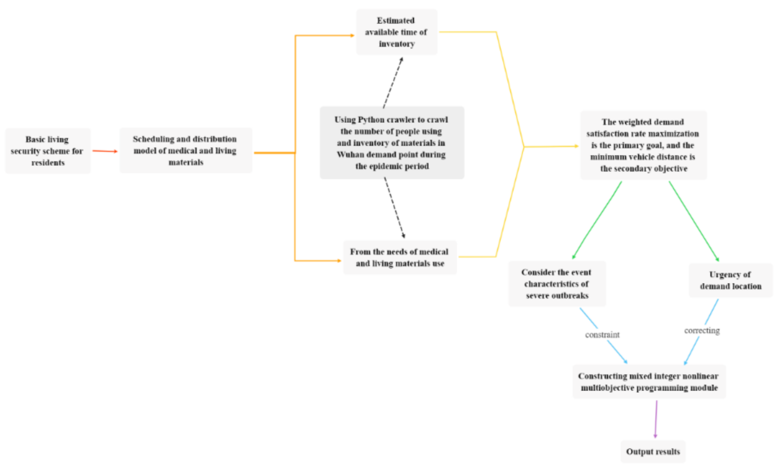


Figure 4-2 Question 1 flow chart

Optimal Material Allocation Model Based On Mixed Integer Multi Objective Programming

Calculation method of important parameters

The number of people affected is the number of people using materials. In order to ignore the influence of dimension, we normalize it as follows

$$\alpha_{jn}^{k}=\frac{p_{jn}^{k}}{\max\limits_{j\in J} p_{jn}^{k}},\forall j\in J,k\in K,n\in N \tag{4-1}$$

Available time

$$t_{jn}^{k}=\frac{Q_{jn}^{k}}{s_{n}^{k}p_{jn}^{k}},\forall j\in J,k\in K,n\in N \tag{4-2}$$

Normalization treatment

$$\beta_{jn}^{k}=\min\left\{\frac{t_{jn}^{k}}{T^{k}},1\right\},\forall j\in J,k\in K,n\in N \tag{4-3}$$

Considering that the shorter the available time of material inventory estimation at demand point is, the higher the degree of urgent shortage of demand should be. The geometric average method is used to calculate the demand urgency

$$\omega_{jn}^{k}=\sqrt{\alpha_{jn}^{k}(1-\beta_{jn}^{k})},\forall j\in J,k\in K,n\in N \tag{4-4}$$

When $\max\limits_{j\in J} t_{jn}^{k}<T^{k}$, the emergency degree of the estimated demand point with the longest available time is zero, and all the demand points may have the same service time, so the normalized value is all equal to 0.

The following objective functions are established:

The main goal is to maximize the weighted sum of demand satisfaction rate. Secondary goal: to pursue the minimization of the sum of distances traveled.

$$\begin{cases}\max Z_1=\sum\limits_{j\in J}\sum\limits_{n\in N}\omega_{jn}^{k}\chi_{jn}^{k};\\ \min Z_2=\sum\limits_{i\in I}\sum\limits_{j\in J}y_{ij}^{k}r_{ij}.\end{cases} \tag{4-5}$$

$$s.t.\begin{cases}\chi_{jn}^{k}=\min\left\{\dfrac{Q_{jn}^{k}+\sum\limits_{i\in I}x_{ijn}^{k}}{D_{jn}^{k}},1\right\},\forall j\in J,k\in K,n\in N;\\ \chi_{jn,\min}^{k}\le\chi_{jn}^{k},\forall j\in J,k\in K,n\in N;\\ \sum\limits_{j\in J}x_{ijn}^{k}\le Q_{in}^{k},\forall i\in I,k\in K,n\in N;\\ y_{ij}^{k}r_{ij}\le r_{\max},\forall i\in I,j\in J,k\in K;\\ \sum y_{ij}^{k}\le M,\forall j\in J,k\in K;\\ x_{ijn}^{k}\left(1-y_{ij}^{k}\right)=0,\forall i\in I,j\in J,k\in K,n\in N;\\ \sum\limits_{i\in I}x_{ijn}^{k}\le\max\left\{D_{jn}^{k}-Q_{jn}^{k},0\right\},\forall j\in J,k\in K,n\in N;\\ x_{ijn}^{k}\ge 0,\forall i\in I,j\in J,k\in K,n\in N;\\ y_{ij}^{k}\in\{0,1\},\forall i\in I,j\in J,k\in K;\end{cases} \tag{4-6}$$

Where x_{ijn}^{k} represents the quantity of living materials n allocated from the centralized distribution center I to the demand point J in the k-th period, y_{ij}^{k} is a 0-1 variable, and the daily necessities are transported from the centralized distribution center I to the demand point J in the k-th period. χ_{ijn}^{k} represents the demand satisfaction rate of demand point J and living materials n in the K period. $\chi_{jn,\min}^{k}$ represents the lower limit value $0<\chi_{\min}<1$ of the demand satisfaction rate of demand point J to living materials n in the K period

4.1.1 model solving

4.1.2 Description Of Allocation Period

Because the cycle length of each allocation period is not required to be exactly the same, it is dynamically adjusted according to the epidemic situation and the supply of medical materials. Considering the time spent in material transportation scheduling, if the next period is allocated after the end of the cycle, the initial demand of the next period may not be met. Therefore, the demand urgency of each demand point is dynamically monitored, and when it exceeds a certain threshold value, the next stage allocation is started.

$$\omega_{jn}^{k} \ge \omega_{\min}, \forall j \in J, k \in K, n \in N \tag{4-7}$$

Among them, $\omega_{\min}$ is the emergency threshold of emergency medical materials scheduling period switching

4.1.3 Data Fitting And Correction

In view of the data errors caused by the nonstandard or non filled data of each region, some automatic correction methods are provided to reduce the error.

We assume that ：

$$\text{Consumption rate of medical materials} = \frac{\text{Material consumption in the previous period}}{\text{Number of users}}$$

$$s_{n}^{k} = \frac{\sum_{j\in J} Q_{jn}^{k-1} + \sum_{i\in I}\sum_{j\in J} x_{ijn}^{k-1} + \sum_{j\in J} Q_{jn}'^{k-1} - \sum_{j\in J} Q_{jn}^{k-1}}{\frac{1}{2}\left(\sum_{j\in J} p_{jn}^{k-1} + \sum_{j\in J} p_{jn}^{k}\right)}, \forall k \in K, n \in N \tag{4-8}$$

If the demand point does not submit inventory information, it can be estimated by formula (24).

$$Q_{jn}^{k} = Q_{jn}^{k-1} + \sum_{i\in I} x_{ijn}^{k-1} + Q_{jn}'^{k-1} - \frac{1}{2}\left(\sum_{j\in J} p_{jn}^{k-1} + \sum_{j\in J} p_{jn}^{k}\right) s_{n}^{k-1}, \quad \forall j \in J, k \in K, n \in N \tag{4-9}$$

Since the demand estimation of each demand point in each stage is greatly affected by human subjective factors, the information of demand points is uncertain. Therefore, we use the method of material consumption rate multiplied by the number of users to assist in the calculation, and consider the estimation error to provide a certain surplus, as shown in formula (25).

$$D_{jn}^{k} = (1+\pi) s_{n}^{k} p_{jn}^{k}, \forall j \in J, k \in K, n \in N \tag{4-10}$$

Where: $Q_{jn}'^{k-1}$ is the quantity of materials n given to the demand point j by means of directional donation in the k-1 period; π is the correction coefficient, $0 \le \pi \le 1$, to prevent the use of the number of users of medical materials at the beginning of period K to estimate the demand when the demand is insufficient.

4.1.4 Model Solving

15 demand points of residents' basic living materials are selected for case analysis, numbered D. Three basic conditions are considered for the selection of centralized distribution center

1. The transportation is convenient for the conversion of various transportation modes;
2. Sufficient warehouse capacity to store and transfer emergency materials;
3. It is not easy to be affected by virus and the materials are relatively safe.

Finally, five centralized distribution centers are selected, numbered as C. Two kinds of emergency materials, basic living materials and medical materials, are discussed. The number of users and inventory of materials at each demand point are shown in Table 2

Figure 4-3 Number of users and inventory of demand points

No.	p_{j1}^k	p_{j2}^k	Q_{j1}^k	Q_{j2}^k	ω_{j1}^k	ω_{j2}^k
D1	400	500	500	1000	0.80	0.65
D2	300	500	1000	500	0.52	0.79
D3	500	600	1000	500	0.82	0.89
D4	300	400	500	1000	0.66	0.50
D5	500	300	500	500	0.91	0.54
D6	400	300	1000	1000	0.68	0.29
D7	300	200	1500	500	0.32	0.35
D8	400	400	3000	2000	0	0
D9	500	600	500	300	0.91	0.94
D10	400	400	500	500	0.80	0.68
D11	500	500	1500	500	0.71	0.79
D12	300	200	500	1500	0.66	0
D13	400	300	1000	1000	0.68	0.29
D14	200	300	500	500	0.48	0.54
D15	400	400	500	1000	0.80	0.50

The inventory of medical materials in each centralized distribution center is shown in Table 3.

Figure 4-4 Medical supplies inventory of supply hub

N	C	C2	C	C	C
Q_{i1}^k	30 00	1000	40 00	20 00	50 00
Q_{i2}^k	20 00	1000	30 00	10 00	20 00

See Table 4 for the vehicle driving distance from each centralized distribution center to all demand points. The parameter $\chi_{jn,\min}^k$ is taken as 0.6 and $r_{\max}$ as the representative 30km.

Figure 4-5 Vehicle travel distance from supply hub to demand points

r_{ij}	C1	C2	C3	C4	C5
D1	4.4	15	27.2	2.9	15.4
D2	9.9	1.7	18.6	16.8	13.8
D3	33.2	32.9	28.7	33.9	22.4
D4	12.8	6.7	14.5	13.6	14.8

D5	8	12.9	30.1	6.8	19.3
D6	9.1	6.1	18.9	9.9	11.1
D7	11.5	10.6	16.2	12.2	11.2
D8	11	4.1	17.4	14.3	15.6
D9	1.6	12.7	28.8	3.5	15.9
D10	1.9	12.1	24.9	2.9	15.3
D11	13.6	12.2	27.6	16.3	32.7
D12	11.1	11.3	27.1	11.9	32.2
D13	7.1	16.2	29	4.7	16.9
D14	9.9	21.4	35.3	6.5	13.2
D15	11.4	3.8	18.4	14.2	17.6

Matlab software is used to import data and then programming to realize the model. The calculation results are shown in Table 5 by using the optimization function intlinprog.

Figure 4-6 Demand satisfaction rate of each demand point

Demand point J	Deployment from centralized distribution center I	x_{ij1}^k	x_{ij2}^k	χ_{j1}^k	χ_{j2}^k
D1	C5	1900	200	1	0.6
	C2	260	0		
D2	C3	0	1500	0.7	1
D3	C3	800	1500	0.6	0.83
D4	C3	1300	0	1	0.63
D5	C4	1360	700	0.62	1
D6	C2	440	0	0.6	0.83
D7	C5	0	300	0.83	1
D8	—	0	0	1	1
D9	C1	0	1200	0.97	0.96
	C5	2400	800		
D10	C1	1700	800	1	1
	C4	200	300		
D11	C2	300	1000	0.6	0.75
D12	C1	1300	0	1	1
D13	C4	440	0	0.6	0.83
D14	C5	700	700	1	1
D15	C3	1900	0	1	0.63

4.1.5 Result Analysis

It can be seen from the results in Table 5 that when the epidemic situation is serious, the optimal basic living security plan for residents in this city is as follows:

Each demand location can allocate materials from the nearest two centralized distribution centers at most

- **Efficiency Analysis**

In order to improve the material demand satisfaction of the demand location as much as possible.

- **Equity Analysis**

It avoids the influence on fair distribution due to the demand difference of each demand location.

If the demand location D8 has zero emergency degree, no material will be allocated.

Then, it can reduce the possibility of large material shortage loss at a certain stage of a demand location, and ensure the fairness of material distribution between multiple disaster points, which is in line with the actual situation of emergency rescue. To some extent, each demand location gives priority to the distribution of materials from the nearest centralized distribution center, which meets the principle of nearby transportation, which proves that the model can take into account the fairness and efficiency of emergency medical materials distribution.

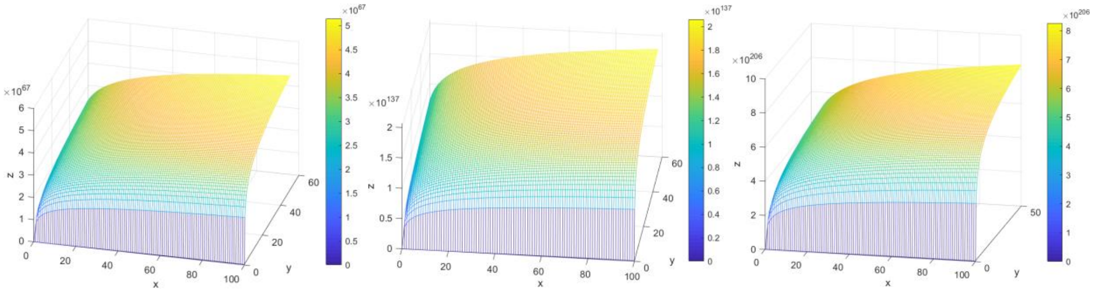
4.2 Model Establishment Of Problem Two

4.2.1 Definition Of Epidemic Level

The number of employees returning to work in E_i comes from K_i regions, of which the number of employees in the k^{th} region is In the statistical analysis, based on the "three color epidemic map" evaluation strategy of a province, the epidemic risk level R_{ik} (Varied from1 to 3, corresponding to low risk, medium risk and high risk respectively), and the traffic time T_{ik} from the area to the enterprise location were obtained, and then the return transmission risk ($1 \leqslant K \leqslant K_i$) was estimated

$$R_{iK}^{(T)} = b^{r_{iK} \log_2(1+s_{iK}t_{iK})} - 1 \tag{4-11}$$

Where b is a constant greater than 1 (we assume it's 1.18 in this paper). This is an empirical formula that we extracted from practice. It shows that the $R_{iK}^{(T)}$ of communication risk increases exponentially with the increase of R_{ik} and $\log_2(1+s_{ik}t_{ik})$.



Low risk area medium risk area high risk area

Figure 4-7 Numerical variation chart of risk of personnel return propagation

4.2.2 Preparation Of Return To Work Production Model Under Different Epidemic Levels

(1) Variable selection and data source preparation

As for the choice of the explained variables, in order to reasonably evaluate the impact of the epidemic on the catering industry, this paper mainly uses the relevant data of the added value of the tertiary industry in China, analyzes and forecasts the impact of the epidemic on the added value of the catering industry and the main business income. As for the choice of explanatory variables, the main factors affecting the development of China's tertiary industry include: the level of national economic development, the level of consumer prices, labor supply, industrial capital investment, urbanization level, import and export trade and so on.

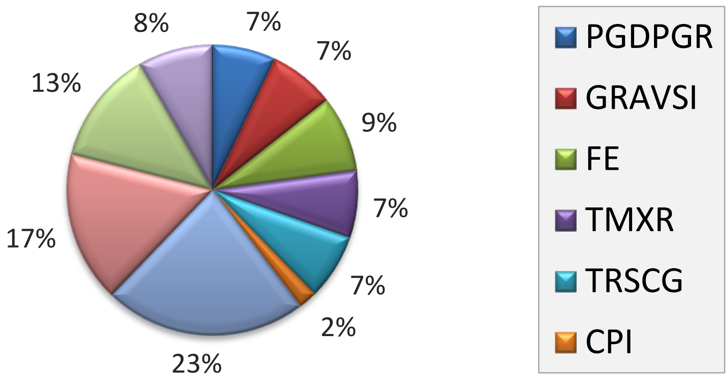


Figure 4-8 Pie chart of main variables

At the same time, considering that the tertiary industry is the downstream industry of the secondary industry, which is greatly affected by the secondary industry, it is necessary to take it into consideration. Therefore, the explanatory variables selected in this paper are: the growth rate of per capita GDP, the growth rate of added value of the secondary industry, the growth rate of fiscal expenditure, the growth rate of total import and export, the growth rate of total retail sales of social consumer goods, the consumer price index of residents, the urbanization rate, the proportion of employees in the tertiary industry, and the growth rate of fixed asset investment in the tertiary industry. Among them, the sample data of the growth rate of added value of the tertiary industry are mainly from the relevant quarterly indicators of the National Bureau of statistics from 2011 to 2019.

(2) Establishment of multiple regression model

We use Python language and machine integration algorithm to process and analyze the relevant data, and get the descriptive statistics of the main variables in Table 3.

Figure 4-9 Descriptive Statistics Of The Main Variables

Index	Count	Mean	Std	Min	25%	50%	75%	Max
PGDPGR	108	13.76%	7.42%	4.95%	8.46%	10.76%	17.73%	35.86%
GRAVSI	108	14.21%	9.61%	0.78%	6.58%	11.89%	19.23%	42.59%
FE	108	16.54%	11.27%	-50.36%	12.07%	15.88%	21.62%	62.80%
TMXR	108	14.49%	15.76%	-24.95%	4.02%	15.46%	23.49%	78.32%
TRSCG	108	14.22%	9.90%	-46.33%	9.83%	14.31%	19.29%	37.85%
CPI	108	4.05%	5.90%	-2.17%	1.14%	2.15%	4.62%	26.90%
UBR	108	43.77%	10.30%	27.59%	34.69%	43.83%	52.93%	60.60%
EPTI	108	32.67%	7.23%	20.15%	26.89%	31.90%	36.85%	48.00%
IIFA	108	24.75%	21.87%	-27.81%	12.70%	21.97%	26.67%	124.45%
GRAVTI	108	16.17%	6.03%	8.83%	12.19%	13.92%	18.14%	37.54%

According to the above variables, the following multiple regression models can be constructed:

$$GRAVTIt = b_0 + b_1 \times PGDPGR_t + b_2 \times GRAVSI_t + b_3 \times FE_t + b_4 \times TMXR_t + b_5 \times TRSCG_t + b_6 \times CPI_t + b_7 \times UBR_t + b_8 \times EPTI_t + b_9 \times IIFA_t + \varepsilon_t \tag{4-12}$$

Where: b_0, b_1, b_2, ...,b_9 is the parameter to be estimated; t represents different time (quarter); and ε is the correction term of error.

4.2.3 Model Solution

(1) Expression of BayesianRidge model

BayesianRidge model is used to solve the multiple linear regression equation. Firstly, the model assumes that the prior probability, likelihood function and posterior probability are normal distribution, which can be used for parameter regularization in the prediction stage. In ridge regression, *l2* regular term is generally used.

$$p(\omega \mid \lambda) = N\left(\omega \mid \alpha, \lambda^{-1} I_P\right) \tag{4-13}$$

Assuming that ω is a Gaussian prior distribution, the prior parameters of ω can be obtained by spherical Gaussian formula; and in the formula, I_P is the unit matrix, n is the Gaussian distribution, α is the mean value of the super parameter, and λ is the standard deviation. For α and λ, the default prior distribution is:

$$\alpha \sim \Gamma(\alpha_1, \alpha_2), \lambda \sim \Gamma(\lambda_1, \lambda_2) \tag{4-14}$$

Among them, $\alpha1=\alpha2=\lambda1=\lambda2=10^{-6}$, Γ is the gamma distribution, and the L2 regular term used in ridge regression assumes that ω is a Gaussian prior distribution, and the gamma distribution also has a conjugate prior relationship with the Gaussian distribution.

Based on the historical data of several major variables (Appendix), the Bias regression model is invoked from the sklearn library using Python language, and the regression analysis is used to get the regression results of table 5.

Table 5 regression results of BayesianRidge model

VARIABLE	REGRESSION COEFFICIENT	VARIABLE	REGRESSION COEFFICIENT	VARIABLE	REGRESSION COEFFICIENT
PGDPGR	1.318	GRAVSI	0.318	FE	0.01
TMXR	0.048	TRSCG	0.033	CPI	-0.06
UBR	0.009	EPTI	0.183	IIFA	0.022
INTERCEPT	0.107				

Thus, the following model can be obtained:

$$GRAVTI_t = 0.107 + 1.318 \times PGDPGR_t + 0.318 \times GRAVSI_t + 0.010 \times FE_t + 0.048 \times TMXR_t + 0.033 \times TRSCG_t - 0.06 \times CPI_t + 0.009 \times UBR_t + 0.183 \times EPTI_t + 0.022 \times IIFA_t \tag{4-15}$$

(2) Dynamic prediction and evaluation of the impact of epidemic situation on catering enterprises in China

For the impact of the epidemic situation on the growth rate of added value of the tertiary industry, the added value of the catering industry and the main business income of China in the first four quarters of 2020: the resumption rate of catering industry and the recovery rate of production and sales during the epidemic period. We used Python to crawl the currently published data of kaggle, and combined with the progress of epidemic prevention and control and resumption of work and production, and estimated the QFGR and CXHR during the epidemic period from the first quarter to the fourth quarter of 2020 according to the three scenarios of mild, moderate and severe. See Figure 3 for details

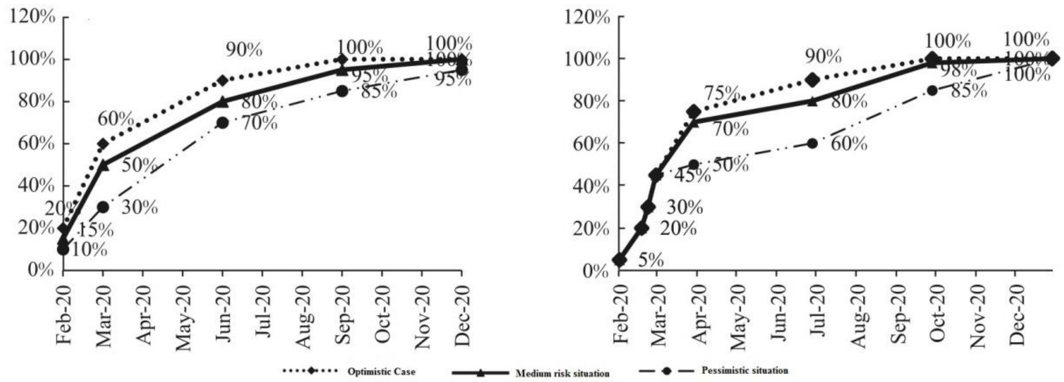


Figure 4-10 Resumption rate and production and marketing recovery rate of catering industry during the epidemic period

Based on the historical data of China's value-added growth rate of the tertiary industry, per capita GDP growth rate, added value growth rate of the secondary industry, growth rate of fiscal expenditure, growth rate of total import and export, growth rate of total retail sales of consumer goods, consumer price index, urbanization rate, proportion of employees in the tertiary industry, and growth rate of fixed asset investment in the tertiary industry in China from 2017 to 2019, The Bayes regression model is used to predict the growth rate of the added value of the tertiary industry in the four quarters of 2020 according to three different scenarios of high risk, medium risk and low risk. Meanwhile, according to the empirical data of China's catering industry, the proportion of industrial added value in GDP is about 60%, which is higher than that of the tertiary industry in GDP (53.9% in 2019), We can get the predicted results of the above explanatory variables and the explained variables: the growth rate of the tertiary industry added value (GRAVTI), the value added of the catering industry (ZXQCZ) and the main business income (ZXYS). For details, see Figure 4 and Tables 6-8

Figure 4-11 Comparison of different situations

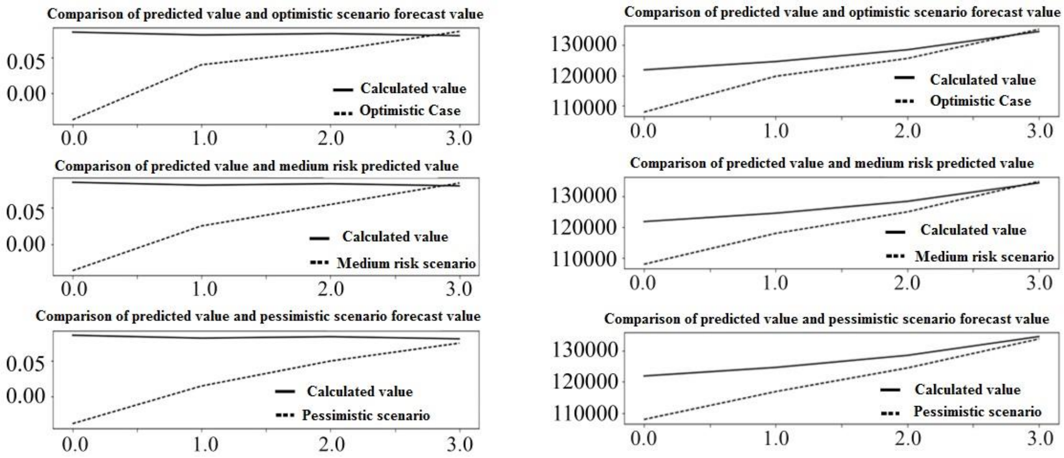


Figure 4-12 Comparison of predicted and predicted values of GRAVTI in 2020 without considering and considering epidemic situation

Quarter	Estimated Value Without Considering Epidemic Situation	Prediction Value Considering Epidemic Situation		
		Low Risk	Medium Risk	High Risk
2020Q1	8.60%	−3.77%	−3.77%	−3.77%
2020Q2	8.20%	4.00%	2.50%	1.50%
2020Q3	8.40%	6.00%	5.50%	5.00%
2020Q4	8.10%	8.70%	8.50%	7.50%

Figure 4-13 Estimation Of Added Value Loss Of Catering Industry In 2020 (unit: 100 million yuan)

Quarter	Estimated Value Without Considering Epidemic Situation	Prediction Value Considering Epidemic Situation			Loss Value Considering Epidemic Situation		
		Low Risk	Medium Risk	High Risk	Low Risk	Medium Risk	High Risk
2020Q1	121 837	107 959	107 959	107 959	-13878	-13878	-13878
2020Q2	124 562	119 727	118 000	116 849	-4835	-6562	-7713
2020Q3	128 417	125 574	124 982	124 389	-2843	-3436	-4028
2020Q4	134 421	135 167	134 918	133 675	746	497	-746
Total	509 237	488 427	485 859	482 872	-20810	-23379	-26365

Figure 4-14 Estimation Of Business Income Loss Of Catering Owners In 2020 (Unit: 100 Million Yuan)

Quarter	Estimated Value Without Considering Epidemic Situation	Prediction Value Considering Epidemic Situation			Loss Value Considering Epidemic Situation		
		Low Risk	Medium Risk	High Risk	Low Risk	Medium Risk	Low Risk
2020Q1	374 882	332 181	332 181	332 181	-42 701	-42 701	-42 701
2020Q2	383 268	368 391	363 077	359 535	-14 877	-20 191	-23 733
2020Q3	395 130	386 381	384 559	382 736	-8 748	-10 571	-12 393
2020Q4	413 602	415 898	415 133	411 307	2 296	1 530	-2 296
Total	1 566 882	1 502 852	1 494 951	1 485 760	-64 031	-71 932	-81 123

It can be seen from table 6-8 that according to the medium risk scenario, the growth rate of added value of the tertiary industry in 2020 will decrease by 4.12 percentage points; According to the calculation of medium risk scenario, the increase rate of added value of the tertiary industry in 2020 will decrease by 4.97 percentage points; According to the high-risk scenario, the growth rate of added value of the tertiary industry in 2020 will decrease by 5.61 percentage points;The government and catering enterprises can combine the above curve forecast chart of production and sales recovery rate and return to work rate, and the estimated value of income loss of main business of catering enterprises to reduce the output of difference value dynamically, so as to minimize the loss of excessive production and sales ratio, that is, to optimize the return to work production plan of catering enterprises under different epidemic levels

4.2.4 Model Testing

In order to evaluate the effect of the actual value and the predicted value, we select the following indicators for model test and selection: interpretable variance, mean absolute error, mean variance, and coefficient of determination. We call the historical data of related variables, using Python language and sklearn. Metrics of machine integration algorithm to process the relevant data, we can get the main evaluation indicators of the above regression model.

Regression Model	Explained Variance	Mae	Mse	R2
Bayesian Ridge	0.6403	0.0063	0.0001	0.6401

MSE measures the degree of deviation between the overall sample and the predicted value of the model. The mean value of the sum of squares of the distance difference $\hat{y}_i$ between the actual value y_i and the predicted value of the first i sample attributes

$$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)^2 \tag{4-16}$$

MSE index measures the dispersion degree of the difference between all prediction values and samples, and the degree of similarity between the dispersion degrees of the sample itself.

$$E\,\mathrm{var} = 1 - \frac{\sum_{i=1}^{n}((y_i - \hat{y}) - E(\bar{y} - \hat{y}))^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{4-17}$$

The closer R^2 is calculated to 1, the closer the predicted value is to the real sample value.

$$R^2 = 1 - \frac{MSE}{Var(Y)} = 1 - \frac{MSE}{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}\right)} \tag{4-18}$$

MAE is the average of absolute errors between predicted and observed values

$$RMSE(X,h) = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(h(x_i) - y_i)^2} \tag{4-19}$$

Data training and testing

This process will train and test the sample data through Python language and machine integration learning, and use cross validation to evaluate the training effect of different models. Cross validation is an effective precision test method to limit the complexity of the model and prevent over fitting. The data should be divided into training set and test set. We used the first 85% data of explanatory variables and explained variables in time sequence for training, and the last 15% data for testing, i.e. 5 times 5 fold cross-over test.

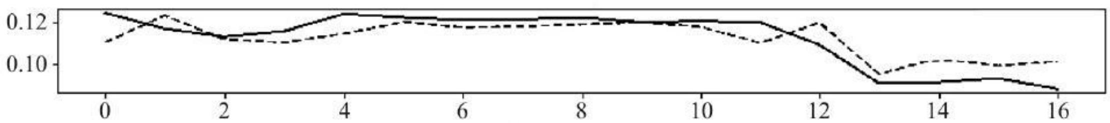


Figure 4-15 Comparison of actual value and Bayesian pair prediction value

4.3 Model Establishment of Problem Three

For problem three, we have designated the national long-term development strategy from the enterprise resumption arrangement. The government management departments need to process the application for resumption of work and production of N enterprises $\{E_1, E_2, \cdots, E_n\}$, and try to restore economic development on the premise that the epidemic prevention and control is not relaxed. Considering the dynamic nature of epidemic risk assessment, this paper assumes a 7-day cycle for decision-making. The decision variable of the problem is recorded as $x = \{x_1, x_2, \cdots, x_n\}$, which is 0-1 distribution. When the value is 1~7, it means that E_i is approved to resume work and production from the X_i day.

For example, there are three risk levels in question two. If the return propagation risk value of an enterprise from a certain region exceeds the threshold value (set as 100), the personnel in the area must return in batches (with an interval of at least 1 day), and the single risk value of each batch shall not exceed the threshold value, and the sum of individual risk values of each batch shall be taken as the calculation result of $R_{iK}^{(T)}$.

4.3.1 Planning Model of Enterprise Resumption

- **Calculation method of important parameters**

Considering the work situation of employees after returning to work, E_i has K_i independent work areas. Among them, the working area of the K working area is A_{ik}, the number of workers is S_{ik}, the average daily working hours is T_{ik} ,and the epidemic risk level of the enterprise location is $1 \le k \le K_i'$

$$R_{iK}^{(W)} = b^{\beta \bullet r_i \log_2 (1 + s_{iK}' t_{iK}' / a_{iK})} - 1 \tag{4-20}$$

Where β is a coefficient, the value is 1 for closed working area and 0.5 for semi open working area. The local area was divided into k areas, and the risk level of the K area was r_k. Based on the residential information of employees in each enterprise E_i, the total number of workers (S_{kk}'(d)) and the average traffic time (T_{kk}'(d)(1≤D≤7;1≤K≤K;1≤K'≤K, where K and K' can be equal, indicating that the residents and work places are in the same district) can be calculated

$$R_{kk'}^{(P)}(d) = b^{\frac{r_k + r_{k'}}{2} \log_2 (1 + s_{kk'}(d) t_{kk'}(d) / \delta_{kk'})} - 1 \tag{4-21}$$

Among them, $\delta_{kk'}$ is the bus frequency from the k^{th} area to the $k^{th'}$ area during the rush hour.

Consider the local M production industries comprehensively. The industrial set of enterprises E_i applying for resumption of work is recorded as Φ_i, and the enterprise set related to industry I_j is recorded as Ψ_j. Each enterprise E_i shall fill in the following information for each industry $I_j \in \Phi_i$ applied for resumption of work:

(1) The number of days τ_{ij} required for enterprise E_i from the date of starting to resume work to the industrial I_j officially resuming production;
(2) The average daily production capacity of enterprise E_i industry I_j after the resumption of production is c_{ij};
(3) The industry I_j of enterprise E_i depends on the upstream industry set A_{ij}, and the capacity c_{ij} of each upstream industry A_{ij} required by the unit capacity of the industry.

Before the start of the current decision-making cycle, the existing capacity of each local industry I_j is o_j, and the cumulative inventory is h_j (for service industries such as transportation industry, the inventory is always 0). If the enterprise E_i starts to resume work on the xi^{th} day, the production capacity c_{ij} of each relevant industry I_j will resume from the date of $x_i + \tau_{ij}$. On the d day of the decision cycle (1≤d≤7), the expected capacity $o_j(d)$ of industry I_j is as follows:

$$o_j\left(d\right)=o_j+\sum_{E_i\in\Psi_j} sign\left(x_i\left(d+1-x_i-\tau_{ij}\right)\right)c_{ij} \quad (4\text{-}22)$$

If E_i recovers its capacity from day $x_i+\tau_{ij}$, then when $d>x_i+\tau_{ij}$, its capacity contribution is c_{ij}.

Before the decision-making, the daily demand of the industry I_j is estimated as $p_j(d)$; due to the new dependence of the industry on the upstream industry, the daily demand after re estimation is as follows:

$$p'_j\left(d\right)=p_j\left(d\right)+\sum_{i=1}^{n}\sum_{I_{j'}\in\Psi_i} sign\left(x_i\left(d+1-x_i-\tau_{ij'}\right)\right)c_{ij'}c'_{ij'j} \tag{4-23}$$

Based on capacity and consumption, I_j's inventory $h_j(d)$ is updated as follows:

$$h_j\left(0\right)=h_j, \tag{4-24}$$

$$h_j\left(d\right)=\max(0,h_j(d-1)+o_j(d-1)-p'_j(d-1)),\quad 1\le d\le 7 \tag{4-25}$$

The total daily demand satisfaction rate of each industry can be estimated as follows:

$$\theta_j\left(d\right)=\frac{\min(h_j(d)+o_j(d)-p'_j(d))}{p'_j(d)} \tag{4-26}$$

In order to quantitatively evaluate the impact of enterprise capacity on local economic and social development, a weight ω_j is set for each industry I_j. At present, our method is to divide them into 10 grades according to their importance. The initial weights of each industry are 20, 16, 12, 10, 8, 6, 4, 3, 2, 1, and then normalize them in the problem, so that the sum of the weights of all industries is 1.

The objective function of the problem is to maximize the total demand satisfaction rate of each industry in the decision-making period

$$\max f\left(x\right)=\sum_{d=1}^{7}\sum_{j=1}^{m}\omega_j\theta_j\left(d\right) \tag{4-27}$$

$$s.t.\begin{cases} h_j(d)+o_j(d)-p_j(d)\ge\sum_{i=1}^{n}\sum_{I_{j'}\in\Phi_i} sign\left(x_i\left(d+1-x_i-\tau_{ij'}\right)\right)c_{ij'}c'_{ij'j}, & 1\le d\le 7;1\le j\le m; \\ \sum_{(i,k)\in\Omega(d)} s_{ik}\le\hat{s}\left(d\right),\ 1\le d\le 7 & \\ \sum_{i=1}^{n}\sum_{k=1}^{K_i}R_{ik}^{(T)}\le\hat{R}^{(T)} & \\ R_{ik}^{(W)}\le\hat{R}^{(W)},\ 1\le i\le n;1\le k\le K'_i; & \\ R_{kk'}^{(P)}\left(d\right)\le\hat{R}^{(P)},\ 1\le d\le 7;1\le k\le K;1\le k'\le K; & \end{cases} \tag{4-28}$$

4.3.2 Model Solution

The greedy strategy is used to arrange the resumption of work and production according to the priority of industrial weight. For each industry ij whose production capacity can not meet the demand, find an enterprise with the largest capacity. If the enterprise does not violate the risk constraint and the upstream industry capacity meets the requirements, the enterprise will be arranged to resume work and production. Otherwise, continue to find the next enterprise with the largest capacity.

Numerical results

In view of the planning demand of enterprises returning to work and production in three places in the last two weeks of February this year, we construct the problem examples and apply the algorithm to solve it. The six problem examples are arranged from small to large according to the scale n, and their basic characteristics are shown in the table below. The fourth column represents the average number of employees from each enterprise's source area, the fifth column represents the average number of employees in each source area, the sixth column represents the average number of related industries of each enterprise, and the seventh table shows the average number of upstream industries associated with each enterprise's industry.

Figure 4-16 Examples of computational problems

ID	n	m	$\frac{\sum_{i=1}^{n} K_i}{n}$	$\frac{\sum_{i=1}^{n}\sum_{k=1}^{K_i} s_{ik}}{\sum_{i=1}^{n} K_i}$	$\frac{\sum_{i=1}^{n}\lvert\Phi_i\rvert}{n}$	$\frac{\sum_{i=1}^{n}\sum_{I_j\in\Phi_i}\lvert\Lambda_{ij}\rvert}{\sum_{i=1}^{n}\lvert\Phi_i\rvert}$
#1	7953	969	25.31	6.70	5.83	2.14
#2	10306	1608	26.27	8.25	4.46	2.46
#3	15541	5010	30.77	11.53	7.26	3.52
#4	18100	6029	31.08	10.96	6.74	4.15
#5	22905	4760	30.72	10.60	5.27	2.75
#6	27032	5833	29.12	11.19	4.81	3.24

The objective function values of greedy strategy are given in Table 2

Figure 4-17 Objective function value of greedy strategy

ID	Greedy Result
#1	662
#2	696
#3	2546
#4	1938
#5	1301
#6	978

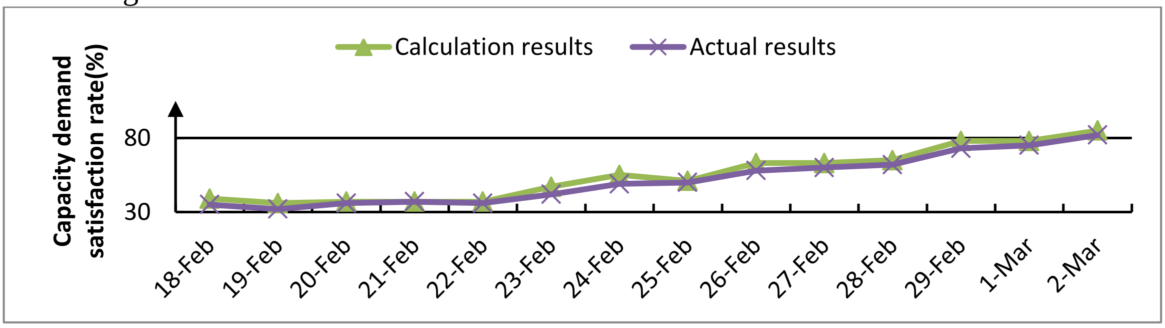
4.3.3 Result analysis

- **Maximization of total demand satisfaction rate**

According to the data in Table 2, the total satisfaction rate of meeting the demand is the largest

- **Effectiveness**

In order to test the effectiveness of the model and algorithm results, we calculated the actual average social demand satisfaction rate of the main industrial capacity (including the industries with initial weights of 20, 16, 12, 10, 8) in a certain three regions during the 7-day resumption period, and compared it with the demand satisfaction rate calculated by the model. The results are shown in Fig. 4, FIG. 5 and Fig. 6.



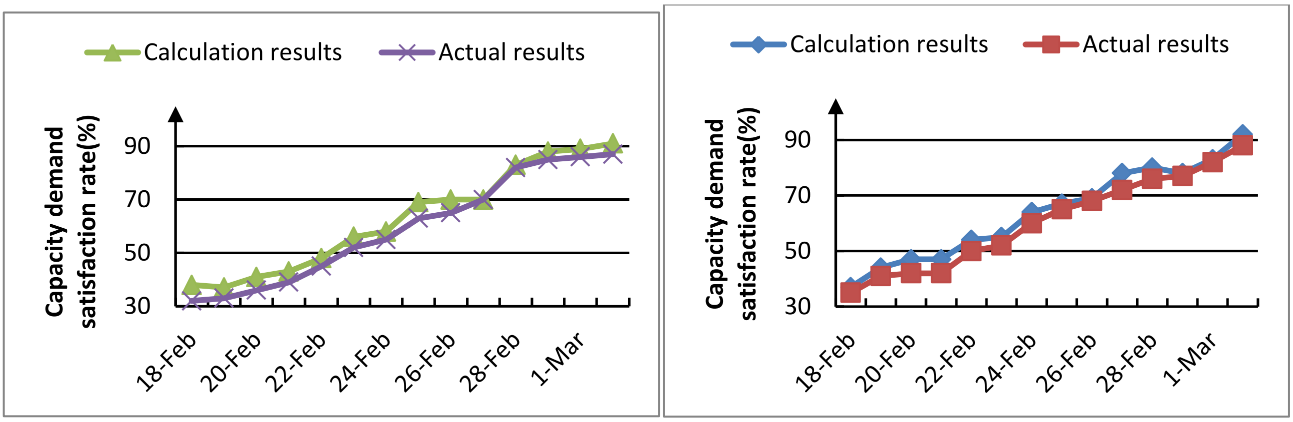


Figure 4-18 Capacity demand satisfaction of three cities

According to figure 4-6, it is found that there is a certain deviation between the calculated scheme and the actual application. It is found that due to the error in the estimation of social demand, there may be delay in the return of employees.

It can be seen from the results that in the statistical period, the production capacity of major industries in each region has increased steadily, which verifies the effectiveness of the planning method proposed by the model. The deviation between the calculation results and the actual results is small, and the trend is consistent, which verifies the rationality of the productivity calculation method in this model. The early error in the arrangement of resumption of work and production is relatively large, because the early production force is weak and is greatly affected by some unexpected interference factors; with the gradual recovery of the industrial capacity, the supply / demand of the upstream and downstream of the industrial chain tends to be reasonable balance, the overall anti-interference ability is enhanced, and the error in the later stage is constantly reduced. In most of the time period, the actual demand satisfaction rate is lower than the calculated value, because the actual production capacity after the interference cannot reach the ideal result calculated according to the model; however, in the later stage, many enterprises will increase the production capacity on the basis of the expected declaration, so some demand satisfaction rate is higher than the calculated value.

4.4 Model Establishment Of Problem Four

4.4.1 Establishment of model

Figure 4-19 **Description and classification of related concepts**

<table>
<tr><th></th><th>Parameter</th><th>Parameter definition</th><th>Parameter type</th></tr>
<tr><td rowspan="4">Influence factor</td><td>Epidemic level</td><td>Number y the largest cumulative number of confirmed cases in each city as of February 28</td><td></td></tr>
<tr><td>Control strength X1</td><td>1. Close 100% restaurants 2. Close 76% restaurants 3. Close 35% restaurants 4. Close 0%</td><td>Ordered variable</td></tr>
<tr><td>Control strength X2</td><td>1.Urban public transport is not stopped 2. Only urban and rural lines are stopped; 3. Urban branch line is stopped; 4. Urban traffic is completely stopped in two stages; 5. Urban public transport is completely stopped</td><td>Ordered variable</td></tr>
<tr><td>Control timeliness X3</td><td>The number of days between the date when the cumulative number of confirmed patients reaches 10 and the implementation date of traffic control</td><td>Numerical variable</td></tr>
<tr><td>Dependent variable</td><td>Economic development level</td><td>2019Annual GDP output value (unit: 1 billion)</td><td>Numerical variable</td></tr>
</table>

Table 4 Definition of variables

Transportation and catering industry novel coronavirus pneumonia is a highly efficient way to spread the virus because of its high capacity of airtight capacity and intensive. In this connection, we combined with relevant data and suggested that the greater the intensity of control and control, the higher the timeliness of control and the more effective reduction of economic development loss (H03). That is, H01: the largest cumulative number of confirmed cases (Y) of the new crown pneumonia virus (COVID, 19) to the economic level (X1).H02: novel coronavirus pneumonia (X3) and X4 (control time) (X4) had negative effects on the largest cumulative number of confirmed Y (COVID) of the new crown pneumonia virus (H03); H03: in the relationship between economic level (X1) and the largest cumulative number of confirmed cases (Y), the control and timeliness (X4) had a mediating effect.

In addition, under the same timeliness of control, different control intensity will also have different impact on the cumulative number of confirmed cases. When the control is not timely, higher control intensity can be adopted to prevent the rapid spread of the virus; if the control is timely, the number of patients diagnosed will be affected by different control intensity, Therefore, we propose that the intensity of management and control plays a moderating role in the second half of the mediating effect (H05) of "economic level → timeliness of management and control → maximum cumulative number of confirmed patients" (H06). Figure 1 shows the model structure

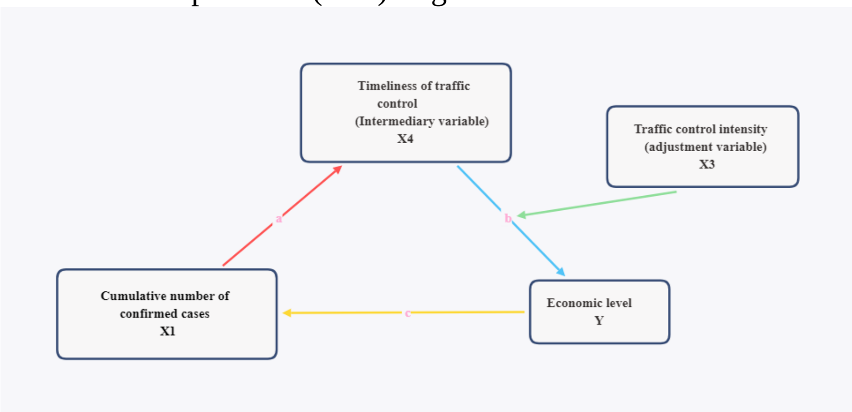


Figure 4-20 Mediation effect model with regulation

There is a moderating mediating effect

The regression equation (7) ~ (9) of mediating effect can be established from the analysis established by the above model

$$Y = cX + e_1 \tag{4-29}$$

$$M = aX + e_2 \tag{4-30}$$

$$Y = c'X + bM + e_3 \tag{4-31}$$

Among them: C is the total effect of X on Y; a and B are the mediating effect; C’ is the direct effect (the relationship between A, B, C’; is shown in Figure 1); the ratio of intermediary effect AB / C represents the percentage of this intermediary effect in the total effect

(3) Correlation analysis model to ensure stable economic development

Table 4 defines the influencing factor group x = [x_1, x_2]The dependent variable group y = [y_1, y_2, y_q] are two groups of random variables; X_i, Y_j are a vector with the length of the number of samples, representing the values of the I, J elements of all samples; a = [a_1, a_2, a_p],b = [b_1 ,b_2 , ..., b_q] are the mapping coefficient matrix, i.e. the weight of corresponding variables X and Y in U and V, as shown in formula (1) ~ (3)

$$Cov\begin{bmatrix} X \\ Y \end{bmatrix} = \Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix}^{1} \tag{4-32}$$

$$U = a \times X = a_1 X_1 + a_2 X_2 + \cdots + a_p X_p{}^{2} \tag{4-33}$$

$$V = b \times X = b_1Y_1 + b_2Y_2 + \cdots + b_pY_p \tag{4-34}$$

Σ_{11} is the covariance matrix of X and X; Σ_{12} is the covariance matrix of X and Y; Σ_{21} is the covariance matrix of Y and X, that is, the transposition of $\sum_{12}$; and $\sum_{22}$ is the covariance matrix of Y and Y

In addition, the canonical correlation analysis is used to calculate the correlation coefficients of two groups of variable coefficient matrix A and B, so as to maximize the correlation between U and V

$$\max p_{(U,V)} = \frac{Cov(U,V) \quad Cov(ax,by)}{\sqrt{Var(U)Var(V)}\sqrt{Var(ax)Var(by)}} \tag{4-35}$$

4.4.2 The solution of the model

We have:

$$S^2 = \frac{\Sigma\left(X - \bar{X}\right)^2}{n-1} 5 \tag{4-36}$$

$$F = \frac{S_{Big}^2}{S_{Small}^2} 6 \tag{4-37}$$

Where: X is the average value of X; n is the number of samples; S^2 is the sample variance; S^2 is the variance of a group of data with larger and smaller variance respectively. By comparing S^2, whether there is systematic error between the two groups of data is determined. Then, the relative size of F and 95% is determined by looking up the table. After that, the relative position (x_2) of epidemic severity (y) is used, Traffic control intensity (x_3) and traffic control timeliness (x_4) were taken as the influencing factors group, and the economic level (x_1) was taken as the dependent variable. After deleting the extreme values in the data, the typical correlation analysis was conducted. The results are shown in Table 5

Figure 4-21 Canonical correlation analysis

influence factor	Mapping coefficient	Canonical correlation coefficient ρ	F	P-Value
X1	0.894			
X2	-0.046	0.846	28.862	0.000
X3	-0.096			

It can be seen from table 5 that the canonical correlation coefficient ρ = 0.846 between the influencing factor group X and the dependent variable y is 0.846, and the F value is greater than its critical value, P<0.001, indicating that the correlation between the influencing factor group and the affected factors (economic development status) is significant. In the canonical correlation analysis, the influence degree of each variable is generally determined by the absolute value of the coefficient in the canonical correlation model, If the absolute value of the corresponding coefficient is larger, the influence degree of the variable on the dependent variable is higher; the influence direction is determined by the coefficient symbol, and the positive sign indicates the positive influence, and the negative sign indicates the negative influence. After that, the mapping coefficient a can judge the order of the absolute value of the coefficient in the influencing factor group x, so as to judge the influence of different control measures

In order to further determine the moderating effect of control intensity on the impact of control timeliness on cumulative number of confirmed people, add the moderating variable (control intensity) to the above mediating effect, and the final result is as follows:

Figure 4-22 Mediation model test with regulation

Parameter	Timeliness of control				Economic development			
	Regressi	Stand	T	P	Regressi	Stand	T	P

	on coefficient	ard error			on coefficient	ard error		
Constant	0	0.115 9	0	1	-0.0954	0.095 4	-0.99 03	0.32 72
Economic level	-0.5736	0.117 0	-4.90 17	0	0.1715	0.159 9	1.07 22	0.28 92
Timeliness of control	-	-	-	-	-0.5833	0.125 9	-4.63 21	0
Control intensity	-	-	-	-	-0.0554	0.110 2	-0.50 30	0.61 74
Timeliness of management and control × strength of control	-	-	-	-	0.2984	0.116 2	2.56 83	0.01 35
R^2	0.3290				0.6362			
F	24.0271				20.1067			

It can be seen from table 9 that after the control intensity is put into the model, the product of control intensity and control timeliness has a significant effect on the prediction of economic development (t =2.5683, P<0.05). In addition, after adding the adjustment variable, R^2 increased from 0.583 2 predicted in the original intermediary model to 0.6362 in Table 9, Table 10 and Figure 2 compare the predictive effect of timeliness of management and control on the cumulative number of patients diagnosed. When the control intensity is low (M+1SD), the 95% confidence interval in table 10 is [-1.3048,-0.4587], and the slope of dotted line in Figure 2 is -0.881 7,It shows that the epidemic level has a significant predictive effect on the economic development level through the mediating effect of timeliness of control; when the control intensity is high (M+1sd), the 95% confidence interval in table 10 is [-0.5276,-0.0421], and the slope of the solid line in figure 2 is -0.2849, indicating that the intermediary effect of timeliness of management and control has little positive predictive effect on economic development

Figure 4-23 Mediation effect on different levels of control intensity

Control intensity	Effect value	Boot standard error	Lower limit of boot CI	Boot CI upper limit
M-1SD	-0.8817	0.2102	-1.3048	-0.4587
M	-0.5833	0.1259	-0.8368	-0.3298
M+1SD	-0.2848	0.1206	-0.5276	-0.0421

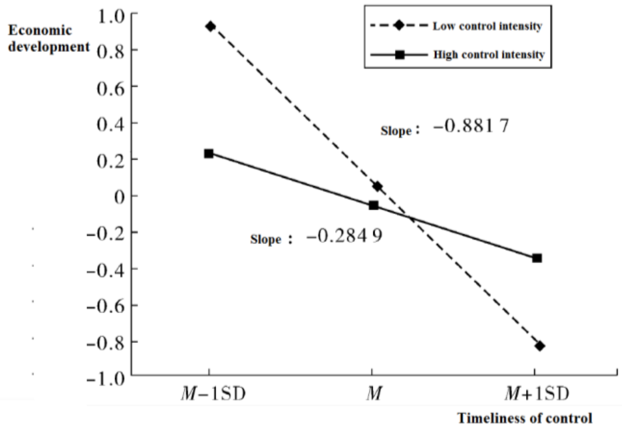


Figure 4-24 regulatory effect of control intensity on the relationship between control timelines and cumulative number of the confirmed patients

In Figure 2, the slope of adjustment effect is negative (- 0.8817 and - 0.2849) for both high-level and low-level management and control, indicating that economic development loss decreases with the increase of timeliness of management and control. Under the intensity of senior management control, the loss of timely management and control (M+1sd) is reduced by 0.579 8 standard deviations compared with that of non-timely management and control (m-1sd);Under the condition of low management and control intensity, the economic damage of timely management and control (M+1sd) is reduced by 1.7734 standard deviations, which is far greater than the impact of management and control timeliness on economic damage under the intensity of senior management control. That is, with the improvement of management and control intensity, the predictive effect of timely management and control on economic development is gradually reduced, and the effect value changes from -0.8817 to -0.2849 (table 10),It shows that the intensity of senior management control can make up for the large-scale infection caused by the untimely control

4.4.3 Model checking

The moderated mediating effect test method is bootstrap method: the mediating effect estimates of each bootstrap are calculated and arranged from small to large. The 2.5 percentile and 97.5 percentile constitute a 95% confidence interval. If 0 is not included, the coefficient product is significant

5 Sensitivity Analysis

The problem considers the situation that the centralized distribution center has been determined, and the temporary centralized distribution center can adjust continuously according to the shortage degree, quantity and location advantage of the supply point. Therefore, we can further explore the dynamic distribution model of urban emergency medical materials considering the location of temporary centralized distribution center in the future.

One-to Two-page Article

Epidemic prevention and control is related to life, and returning to work and production is related to livelihood. When the epidemic situation is serious, in order to ensure the basic life of residents, the three-level emergency material distribution network of "supply point centralized distribution center demand point" should be reasonably coordinated, with the maximization of weighted demand satisfaction rate as the main goal and the principle of nearby transportation as the secondary goal; the fairness and efficiency of material distribution should be taken into account to realize the accurate matching of supply and demand. When allocating materials, we should construct the demand urgency index from two dimensions: the number of users of emergency supplies and the available time of inventory estimation, and quantify the fairness of material distribution by weighted demand satisfaction rate, so as to avoid large shortage of medical materials in each demand point, and make the distribution model meet the actual needs.

In order to deal with the challenge of enterprise return to work and production planning under the condition of epidemic situation, the integer programming problem model can be used to select a part of a large number of candidate enterprises and reasonably arrange their resumption order, so as to maximize the comprehensive capacity demand satisfaction rate of all related industries. In order to improve the universality and accuracy of the model, we can use the estimation methods of return spread risk, work transmission risk and commuting bus transmission risk under epidemic situation. In addition, greedy strategy, variable neighborhood size and re initialization mechanism can be used to improve the efficiency of the planning problem.

In addition, the relevant government departments should take effective financial and financial support policies for SMEs in a timely manner. As soon as possible to repair the industrial chain and supply chain, at the same time to prevent enterprise capital chain fracture.

After the approval of enterprises to return to work and production, it is also necessary to extend the precision prevention and control to the precise scheduling of public transportation and catering services, the comprehensive protection of people's daily life, and the accurate control of employees' health risks, so as to ensure the effect of returning to work and production, and promote the sustained and healthy development of economy and society. These studies are conducive to consolidating the achievements of epidemic prevention and control, resolving the adverse effects of the epidemic situation, and maintaining the healthy development of the economy and society It is of great significance for China's economy to improve for a long time.

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Appendix

Program code 1	Canonical Correlation Analysis

```
clc,clear
loadr.txt      %原始的相关系数矩阵
n1-5;
n2=7;
num-min(n1,n2);
s1=r(1:n1,1:n1);   %提出 X 与 X 相关系数
s12=r(1:n1,n1+1:end); %提出 X 与 Y 的相关系数
s21-s12; %提出 Y 与 X 的相关系数
s2=r(n1+1:end,n1+1:end); %提出 Y 与 Y 的相关系数
m1-inv(s1)*s12* inv(s2)*s21; %计算矩阵 M1
m2-inv(s2)*s21* inv(s1)*s12; %计算矩阵 M2
[vec1,val1]=eig(m1); %求 M1 的特征向量和特征值
fori-1:n1
vec1(:i)=vec1(;i)/sqrt(vec1(:j)*s1*vec1(j)); %特征向量归一化
vec1(,i)=vec1(:i)/sign(sum(v(1(2)); %特征向量乘以 1 或- 1,保证所有分量和为正
end
val1-sqrt(diagval1)); %计算特征值的平方根
[val1,ind1]=sort(al1,'descend); %按照从大到小排列
a=vec1(;ind1(1:num))
%取出 X 组的系数阵
dcoef1=vall(1:num) %提  出典型相关系数
flag=1;
xlswrite("bk. xIs',a,'Sheet1'A1) %把计算结果写到 Excel 文件中去
flag- -n1+2; str-=char(["A'int2str(f1ag)]);
xlswrite(bk xls' ,dcoef1'Sheetl',str)
[vec2,va1l2]=eig(m2);
for i=1:n2
vec2(:i)=vec2(:i)/sqrt(vec2(: ,i)*s2*vec2()); %特征向量归一化
vec2(.i)=vec2(.:i)/sign(sum(veC2.2)); %特征向量乘以 1 或一 1, 保证所有分量和为正
end
val2=sqrt(diag(va12));
%计算特征值的平方根
[va12, ,ind2]-sort(va12,'descend); %按照从大到小排列
b=vec2(: ,ind2(1:num)) %取出  Y 组的系数阵
dcoef2=val2(1:num)
%提出典型相关系数
flag-flag+2; str=char(['A' int2str(flag)]); %str 为 Exce1 中写数据的起始位置
xlswrite(bk xIs',b,'Sheet1',str)
flag=flag+n2+1; str=char('A' ,nt2str(1ag)]); %str 为 Exce1 中写数据的起始位置
xlswrite("bk xls ,dcoef2';Sheet1',str)
x_ _u_ r=s1*a
%x,u 的相关系数
y_ v_ r=s2*b
%y,v 的相关系数
```

```
x_ _v_ r=s12*b
%x,v 的相关系数
y_ u _r=s21*a
%y;u 的相关系数
flag-flag+2; str=char(['A'int2str(flag)]);
xlswrite(bk.xls',x_ u_ r,'Sheet1',str)
flag-flag+n1+1; str=char(['A' .nt2str(flag)]);
xlswrite("bk.xls'.y_ V_ r,'Shet1'str)
flag=flag+n2+1; str=char([A',int2str(flag)]);
xlswrite(bk.xls',x_ V_ r,'Sheetl'str)
flag-flag+n1+1; str=char(['A' ,nt2str(f1ag)]);
xlswrite("bk.xls'.y_ u_ _r,Sheet1',str)
mu=sum(x_ u I:^2)/n1 %x 组  原始变量被 u_解释的方差比例
mv=sum(x_ v_ _r^2)/n1 %x 组  原始变量被 v_ i 解释的方差比例
nu=sum(y_ _u_ I^2)/n2 %y 组  原始变量被 u_ i 解释的方差比例
nv=sum(y_ v_ I^2)n2 %y 组  原始变量被 v_ ji 解释的方差比例
```

Program code 2	Mixed integer linear regression

```
f=[z11max z2max];
A=[1 1;5 9];
b=[6 45];
lb = [z11min , z2min]; %  约束条件下端
ub = [z2min , z2max]; %  约束条件下端
Aeq = []; % Aeq*x = beq  如果没有等式用[]代替
beq = [] ;
intcon=[1 2]; %决策变量所在位置
[x,fval]=intlinprog(f,intcon,A,b,Aeq,beq,lb,ub);
x,fval=-fval %最大化目标函数转换成最小化目标
```

Program code 3	Greedy Algorithm

```
%  产业按照优先级排序

d = 1; %  天数
RT = 0; %  传播风险
% E = [7953, 10306, 15541, 18100, 22905, 27032]; %  需要处理企业个数
n = 7953;
hj = 0; %  库存量
% m = [969, 1608, 5010, 6029, 4760, 5833]; %  生产产业个数
m = 969;
%k = [25.31, 26.27, 30.77, 31.08, 30.72, 29.12] %  各企业员工来源地平均数量
k = 25.31
% a = [2.14,2.46,3.52,4.15,2.75,3.24]: %各企业关联上游产业平均数量
a = 2.14;
tao = 10; %  从复工到正式恢复需要天数
oj(d) = 100;
while(d <= 7)
```

```
        j=1; %  被排序的产业顺序
        Rp(d)=0;%人员公交每日传播风险
        while(j <= m)
                oj(d)=oj; %  预产能
                if(tao <= d)
                E1 = j;
                end
                while((hj(d)+oj(d) < pj(d) ) && (E1 ~= 0)) %  上游产业产能满足别难过且
                        E(i) = max(c(j)) %  选择产能最大的企业  c(j)日均产能
                        j = j+1;
                end
                d = d+1;
        end
end
E1
```

Program code 4	Bayesian regression model

```
import numpy as np
import pandas as pd
from sklearn import datasets, linear_model
from sklearn.cross_validation import train_test_split
from sklearn import metrics
from sklearn import preprocessing

from sklearn.naive_bayes import GaussianNB
from sklearn import linear_model

from sklearn import metrics



def Bayes(path):
        data = pd.read_excel(path)
        data.dropna(inplace=True)
        array=data.values
        X=array[:,1:len(data.columns)-1]
        y=array[:,len(data.columns)-1]
        X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)


        reg=linear_model.BayesianRidge()
        reg_=reg.fit(X_train, y_train)
        y_pred = reg.predict(X_test)
        return (X_test,y_pred)
x,y=Bayes("./test.xls")
print (x,y)
```