

Team Number :	2020170020013
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Problem Chosen :	B
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2020 APMCM summary sheet

Analysis of the impact of US Presidential Candidates' Policy on China and US Economy Based on Linear Regression and Cobb-Douglas Function

Abstract

2020 is the year of the new presidential election of the United States. Who will win this election, Trump or Biden, will have a profound impact on the **economy** of the United States, China and even the world. Based on this, this paper analyzes the policies of the two candidates by using the collected data and economic principles. When solving Question 1, we choose their policies about COVID-19, employment and environmental problem to analyse impact on **economy** of US. In Question 2, tariffs of US will influence the trade between US and China which affects Chinese economy. Collected data contains the number of infected people, the number of labour force, the unemployment rate, GDP, total tariffs, total trade, the percentage of renewable energy consumed, etc. In this text we try our best to use **linear regression** more to fit data and fortunately the accuracy is exceedingly high. When discussing the impact of labour force, we used **Cobb-Douglas function** to help solve the problem and it is really useful. And when discussing the COVID-19, we considered government's effect and established a model consisting a linear part and a fractional part. In Question 3, we give some suggestions according to conclusions in Question 1 and Question 2. Finally we evaluated our models and point out their advantages and disadvantages. The models are based on economic theory, and the methods are reliable with previous experiments. The related data is collected through official networks. It is reliable and new, and can truly reflect the real information.

Keywords: economy, linear regression, Cobb-Douglas function

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1. Introduction

1.1 background

2020 is the year of the US presidential election. The two candidates have many completely different policies. One is Donald Trump, Republican Candidate. The other is Joe Biden, Democratic counterpart. Their running for president is amazingly fierce. At the same time, we are more curious about how their policies will affect the US economy and how the economy of China will be infected. It will be better if we can build a mathematical model to analysis this question more accuracy. Based on this, this text aims to compare their policies. And For some important aspects, we will establish related mathematical model to analysis each factor's infect on the economy.

First of All we can see the differences of policies between Trump and Biden as chart 1:

	Donald Trump	Joe Biden
COVID-19 measures	Trump has long opposed to wear masks and WHO out, thinking that the COVID-19 is not a big problem.	Biden proposed a mandatory "mask order" to actively promote virus testing, back to WHO.
Employment	Trump advocated economic policies and achievements during his administration, and emphasizing the role of economic growth in driving employment and income growth	Biden opposed tax cuts, placing greater emphasis on job-related government guarantees that raise the minimum wage and promote racial equality
Medical insurance	Trump advocates reducing health care costs through market competition instead of government's policy.	Biden is focused on government intervention and wants to promote and improve Obama's Affordable Care Act
Environmental protection	Trump insists on developing traditional energy sources and withdrawing from the Paris Climate Agreement	Biden is focusing on new energy and plans to return to the Paris climate agreement
Trade	Trump continues to insist on imposing punitive tariffs on countries that carry out	Biden does not support the use of tariff weapons, but is also

	unfair dumping and subsidies.	concerned about "unfair competition" and tends to press "trade policy abusers" such as China through uniting allies.
Foreign policy	Trump continues to emphasize "America first ", restoring America's position in global diplomacy, reshaping American military power and allowing allies to bear more defense costs	Biden stressed foreign solidarity, hoping to rebuild alliances and end the war in Afghanistan and the Middle East

Chart 1. the differences between Trump's policy and Biden's

Our model is also based on these factors including COVID-19, Employment and Environmental protection, Trade etc. We will analysis each factor's influence on economy.

1.2 Restatement of the Problems

Question 1 requires us to establish a mathematical model to quantitatively analysis the possible impact on US economy. We can choose some important fields and analysis them separately.

Question 2 is similar to Question 1, but now we study the impact on China instead of US. That will be more complex. But we still can choose the factors we think vital.

Question 3 is based on the conclusion we conduct in Question 1&Question 2. We're required to give suggestions upon China's economy and related fields.

2. Problem Analysis

2.1 Question 1

Before we start to analysis there is a problem needs to solve: How to evaluate economic impact with a numerical variable? Now that Question1 requires to study the impact on US, we can choose GDP each year as our evaluate target. First of all, we need to collect GDP data in these years. Then after analysis, the chosen fields are COVID-19 measurements, employment and environmental protection. All of these factors will be studied separately.

For COVID-19, we use employment rate as an intermediate variable to build up relationship between COVID and GDP. The number of infected will infect employment rate while government could help lessen that burden. So we take COVID and government into

consideration since they resist the other one.

For employment, we use the quantity of labor force as evaluating indicator, and according to economic theory, Cobb-Douglas Function is widely used to show the relationship between input(including labor and capital input) and output(there we choose GDP). And we will use our collected data from world bank to fit the function and solve out all the constants.

For environmental protection, it's always a hot spot in presidential elements. The main point why Trump and Biden disagree with each other lies in that whether use renewable energy more. So we choose the percentage of renewable energy consumed (compared to all kinds of energy consumed in US) as our factor's indicator.

2.2 Question 2

Question 2 requires to analysis the impact on China, so it's not appropriate if we still choose GDP as the evaluate target. At this time, we choose total trade between China and US as our target. Trade policy and have great impact on economy of China so we just analysis the trade policy's infect on trade.

2.3 Question 3

Question 3 is based on 1&2, so 1&2 must be solved and then we can say what policy is better for China and US.

3. Assumptions and Symbols Description

3.1 Assumptions

1. All factors we discuss is separate to each other
2. When using linear regression, if $R^2 > 90\%$ we think the model has a strong linear correlation.

3.2 Symbols Description

When you read the text you find symbols not covered in Chart 2, please understand meaning of the symbol with explain in the text.

Symbols	Definitions
$r(t)$	The number of existing COVID-19 infections

$f(t)$	The employment rate at time t
$g(t)$	Shows the government intervention
t	time
F	GDP
L	The number of labor force (10000 people)
K	Total fixed asset formation current price USD
A	technology
E	the use of renewable energy (%)
R	Total tariffs of US
Q	Total trade between US and China
α, β	Constants in linear model to solve

Chart 2. Symbols and their descriptions

4. Model Establishment and Solution

4.1 Model and Solution of Question 1

Before to analysis, we collected related GDP data these years as our evaluate target, and the data will be shown as figure 1 below (data from: <http://dc.xinhua08.com/65/>):

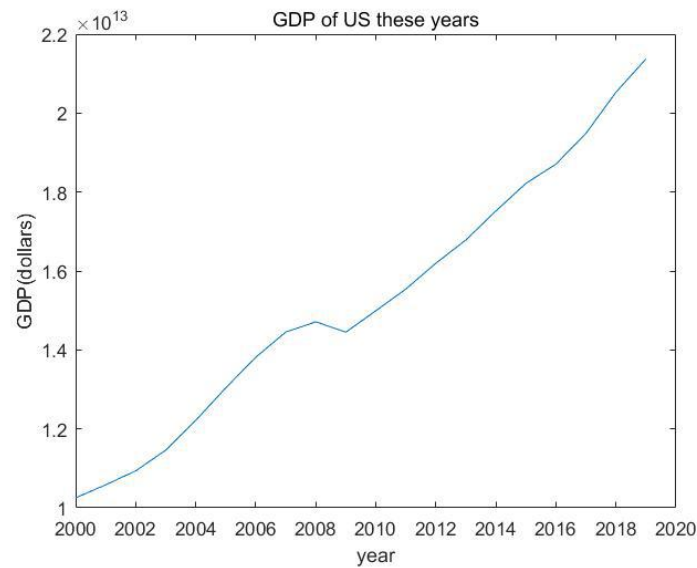


Figure 1. the GDP of US each year, y is GDP

This year, because of the COVID-19's impact, the economy of US is decreasing rapidly. Whether the new president can stop the decrease of economy or even make economy increase again is the key to win. Now we conduct models to discuss 3 possible factors' influence on economy (GDP):

(1) COVID-19 measurements

COVID-19 in 2020 is a big threat to economy. First, we collected data of number of infected persons $r(t)$, and analysis the change of $r(t)$ (10^4 people) with time t (month), and we use linear regression to fit the data and get equation(1) below:

$$r(t) = \begin{cases} 152.41t - 549.39 & (t > 3) \\ 0 & (t \leq 2) \end{cases} \quad (1)$$

The R^2 score is 94.87%, meaning that $r(t)$ is linear correlate to t . because before March there is nearly no people infected, so we think before March $r(t)=0$.

Figure 2 shows the fitting accuracy:

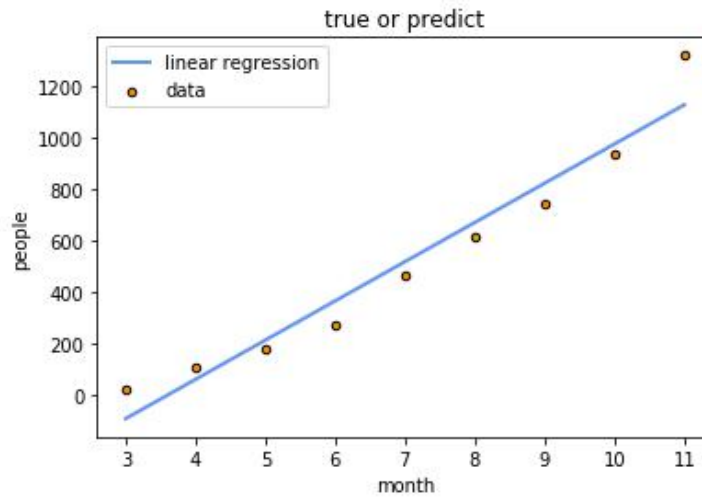


Figure 2. the infected people from 2020.03-2020.11

The wide spread of COVID-19 seriously infects the employment rate, so we'll establish model of employment rate next. Assume that the employment rate $f(t)$ is infected by COVID-19 and government's help $g(t)$. Before government take a part in anti-COVID-19 work, $f(t)$ is related to $r(t)$. The more people infected, the $f(t)$ decrease. So, we use fractional function to establish model as equation (2):

$$f(t) = f_0 \left(\frac{1}{1 + r_0 r(t)} \right) \quad (2)$$

There f_0 and r_0 are constants. f_0 is the initial employment rate equaling to 96.39%. But considering Trump government's work, we add $g(t)$ to show the government's help. That will lessen impact of the epidemic of the economy. If we see $g(t)$ is linear correlated to t , and we will get equation (3) and equation (4):

$$f(t) = f_0 \left(\frac{1}{1 + r_0 r(t)} + g(t) \right) \quad (3)$$

$$g(t) = \alpha t + \beta \quad (4)$$

We use programming to solve three constants waiting to solve, and finally solved that $r_0=2.8$, $\alpha=-0.014$, $\beta=1.012$. The R^2 score is 99.46%, showing that the model has an exceedingly high accuracy. Figure 3 shows the predicted data and true data:

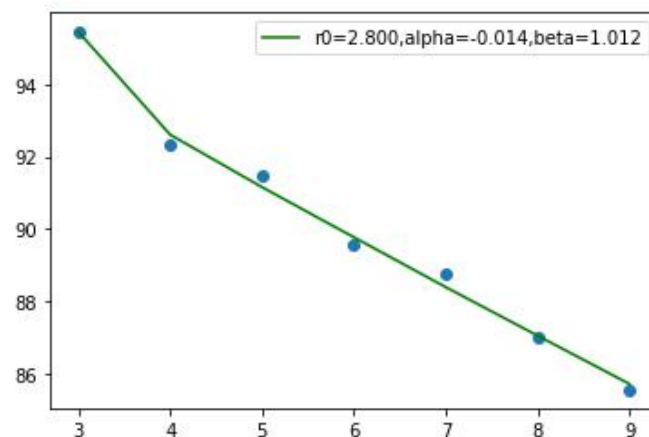


Figure 3. true data with predicted data, x-ray is month, y-ray is employment rate

To make $f(t)$ higher, on one hand, we need to make $r(t)$ less or $g(t)$ higher. If Trump still not stop the booming of COVID-19, $r(t)$ will be higher and higher and finally, $g(t)$ is necessary because the fraction part is nearly 0. $\alpha < 0$, that means if government still don't take some strong action to increase β , $g(t)$ will decrease.

If Trump is chosen to be the new president, after 4 years, $g(t)$ is 0.34, only 33.6% of initial government's impact. And after 4 years without control, the $r(t)$ will be 8.138×10^7 people, so the fraction part can be seen as 0 and the employment rate finally will be $0.34 \times 96.39\% = 32.77\%$. That is too dangerous. But if Biden is chosen to be the president, he will cut down $r(t)$ and raise β so the situation might be eased. Especially $r(t)$, if he cut down COVID-19 infected people into thousands of people, the employment rate will rise about 0.73 times of initial value.

Then we take rework policy in May into consideration, which means before May $g(t)=0$, and we think equation (4) can be changed as equation (5):

$$g(t) = \alpha(t - 4)^\beta \quad (5)$$

Then we calculated it and we solved that $r_0 = -153.73$, $\alpha = 0.914$, $\beta = 0.000$. That is strange, so the equation (5) might be not suitable.

After analyzing the relation between $r(t)$, $g(t)$ and $f(t)$, now we need to analyze $f(t)$ and F . In our intuitive feeling, F is positively relevant to $f(t)$. we analysis the data and find that although there isn't exist a clear math equation to show the relation between $f(t)$ and F even in linear format, the $f(t)$ is truly positively relevant to F . So, if the new president can boost $f(t)$, GDP will rise.

(2) Employment

For employment and labor, we choose Cobb-Douglas function (then we call it C-D function) to fit data we collected after referred to related information. C-D function describes the relationship between input and output, and the input includes technology, labor force (unit: 10000 people) and capital input (unit: million dollars). There we use F to substitute total GDP of US as we show in Figure 1. A symbolizes technology and we assume it a constant. L is the number of labor force, K is Total fixed asset formation current price USD to show the capital input. Then we can establish model below:

$$F = AL^{\alpha} K^{\beta} \quad (6)$$

There α and β are constants to solve out. The C-D function seems a little difficult to fit, so we logarithms of both sides in equation (6) above, and we can conduct equation (7) below:

$$\ln F = \alpha \ln L + \beta \ln K + \ln A \quad (7)$$

Then equation (7) can be seen as a simple linear regression. We use processed data to analysis and we find that the data we collected has very strong linear correlation, the R^2 score is 98.9%, really high. And we finally solved out that $\alpha=4.7395$, $\beta=0.2284$, $A=1.864 \times 10^{-20}$. That means, the form of equation (6) can be solved as equation (8), and we got related images in the process of fitting C-D function model.

$$F = (1.864 \times 10^{-20}) K^{0.224} L^{4.7395} \quad (8)$$

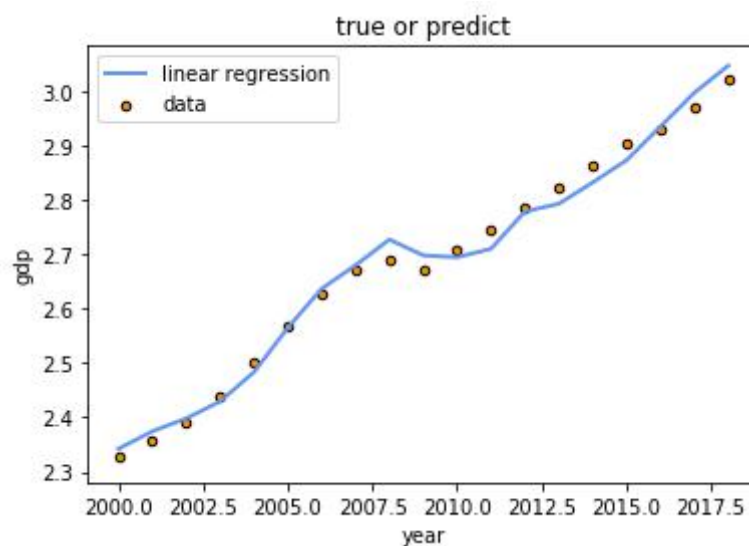


Figure 4. predict data and real data of GDP

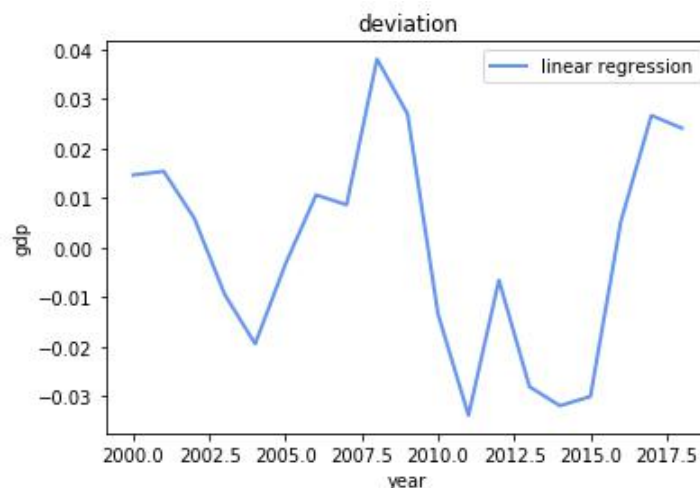


Figure 5. deviation between real data and predict data

From this model we can see that GDP is related to labor force, capital input and technology. Since we assume the technology is a constant, after assure the Total fixed assets formation current price USD, we just need to compare the different policy and analysis the impact on labor force. We use regression tools in MATLAB to predict K in 2020, the predict K is 4109430189473.656. Then we analysis the difference between Trump and Biden about labor force:

Trump likes to show his great success in economy, emphasize economy increase to increase labor force instead of increase labor force to stimulate economy. So, Trump seems not willing to take measures to increase labor force. The rate of unemployment in 2020 is nearly 3-4 times than 2019. That means, if Trump still think little of labor force and don't take any measures, the economy will decrease rapidly. If subtract out the number of covid-19 cases, America's Labor force is three percentage points smaller than it was last year, though it is still steadily rising. Next year, the COVID-19 hang over may show up, and the U.S. labor force may see a sharp decline.

Biden takes useful measures to stimulate economy. He will take actions to reduce the number of people infected to increase labours. He placing greater emphasis on job-related government guarantees. He aims to raise the minimum wage to stimulate labor force, that may make labor force stop decreasing and even increase labor force. Subtracting 50 per cent of cases would reduce the Labor force by 1.2 percentage points. And with his policies of wage, more people are willing to work so we can add some people, which means that the subtract people are less than 50% percent of infected people and labour force will drop within 1.2%. At the same time, he is opposed to lessen taxes, and then the K will increase. So, his policy of

employment is better for US's economy.

(3) Environment protection

Topics about environment and energy is always a hot spot every time of element for president. Trump support traditional energy while Biden support renewable energy more. So now we begin to discuss the relationship between GDP and the percentage renewable energy consumed.

After our analysis, we think there is a strong linear correlation between the percentage renewable energy consumed compared to total energy consume and GDP. Use $E(\%)$ to symbolize the use of renewable energy(%), and we establish a linear model as equation (9):

$$F = \alpha E + \beta \quad (9)$$

Then after programming we solved weight α and bias β . R^2 score is 92% and got equation (10) and figure 6 below.:

$$F = 1.63E + 2.9858 \times 10^{12} \quad (10)$$

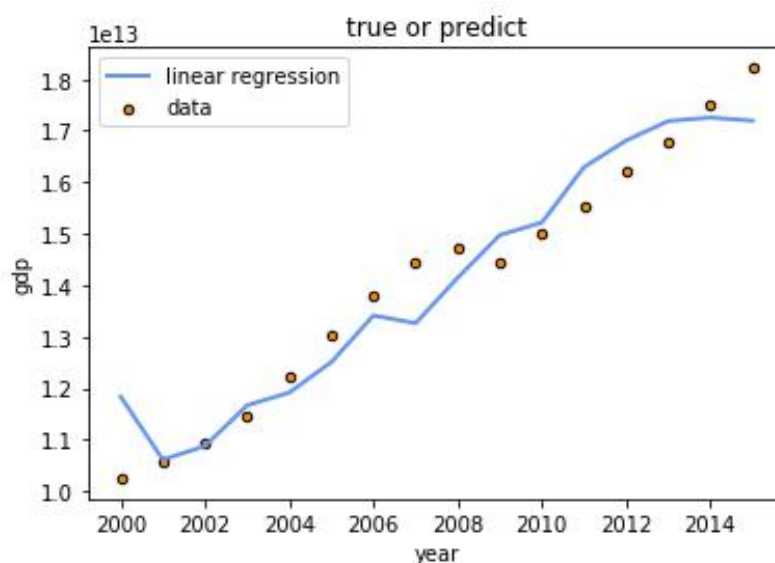


Figure 6. the predicted data and real data each year

There we can clearly see that the more you use renewable energy the greater GDP will be. So, let Biden be the president and promoting the use of renewable energy will benefit GDP of US.

4.2 Model and Solution of Question 2

Now the evaluate target will be changed to total trade between US and China. We also

collected related data and shown as figure 7 and figure 8 below. We can see these important data between China and America: Total trade, Chinese imports to the United States, Chinese exports to the United States, trade surplus.

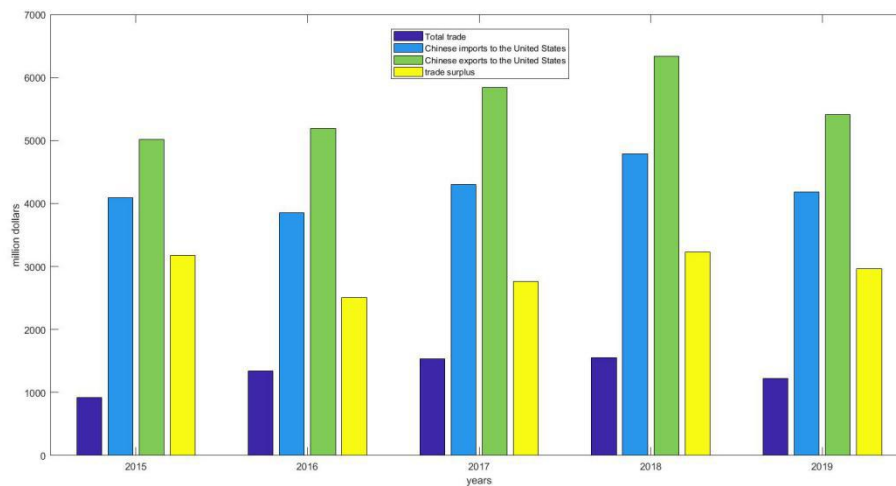


Figure 7. The related data about trade between China and US in 2015-2019

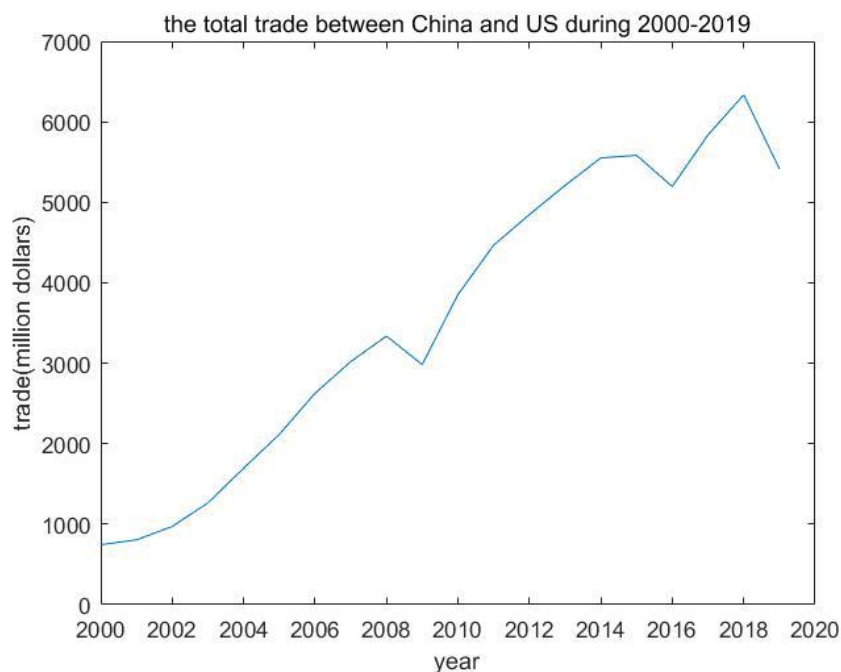


Figure 8. The total trade between China and US during 2000-2019

This year with Trump's more severe policy and attitude about China, the trade between China and US dropped rapidly. To make sure what policy to China is better, we choose the Trade policy and Foreign policy as factors to analysis:

(1) Trade policy

The biggest difference between Trump and Biden in Trade is that: Trump insist on restrictions on trade with China while Biden doesn't support to use tariffs as weapons to punish China but still not be friendly to China. So there if we wanna analysis impact on total trade made by their trade policy, we can choose tariffs to China as factor to show their different opinion upon China.

Figure 9 below shows the total tariffs of US(data from the world bank). we can see that in 2019 tariffs has a rapid increase. That was because of the Trade War between China and US, and it also made the total trade of China and US less than 2018 according to figure 8. We can feel that the tariffs are related to the total trade.

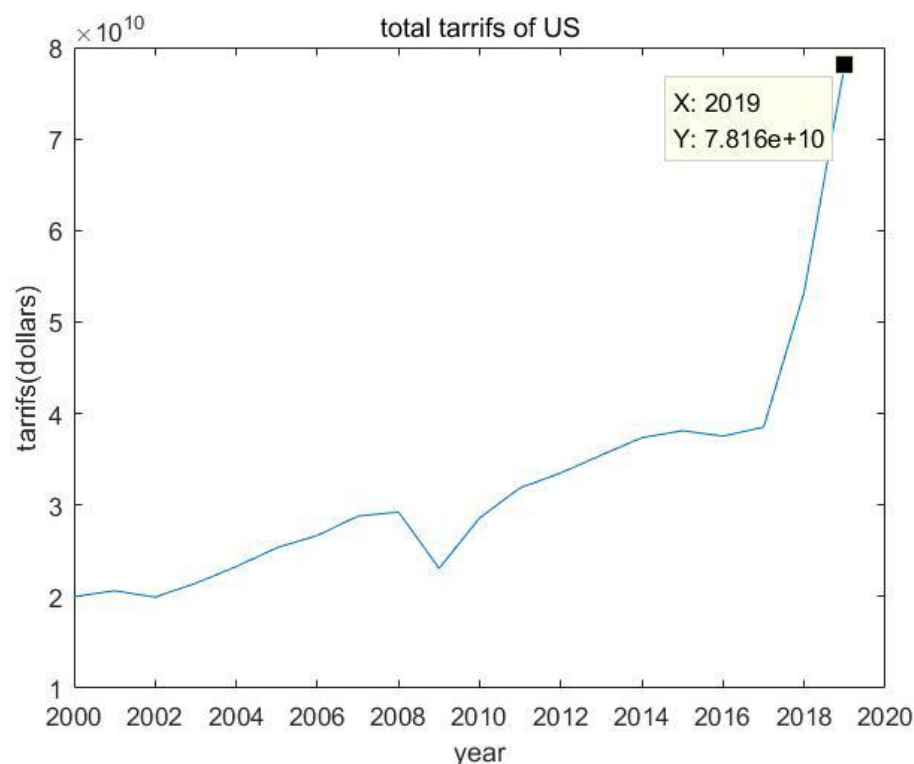


Figure 9. total tariffs of US from 2000 to 2020(dollars)

We discuss total tariffs first. In figure 8 and figure 9 we can see that in 2008-2009, both trade and tariffs decreased. The reason might be some political reason, but see 2000-2008 and 2009-2017, with tariffs rise the trade rise too; and after 2017 the tariffs increased sharply but the trade began to decrease. After our analysis, we find that before 2016 the tariffs have a strong correlation with trade. And we solve the equation between tariffs (R) and trade (Q) as equation (11):

$$Q = (3.511 \times 10^6)R + 1.694 \times 10^{10} \quad (11)$$

The R^2 score is 94.6%, very strong linear character. And we can draw figure 10 and 11:

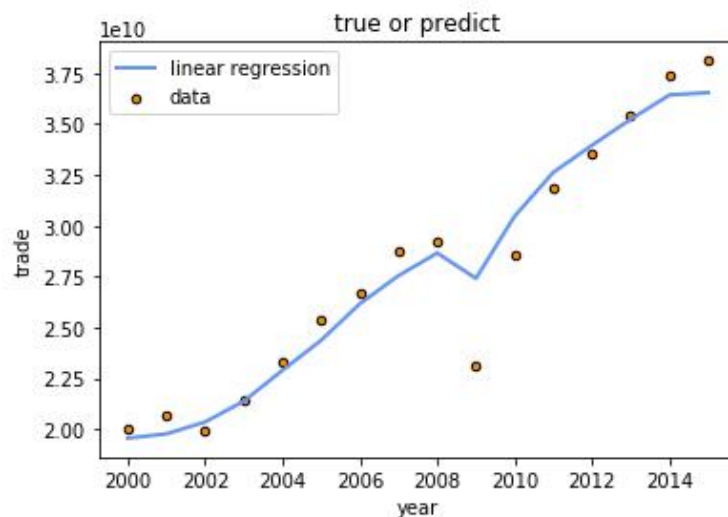


Figure 10. true trade data and predicted data during 2000-2015

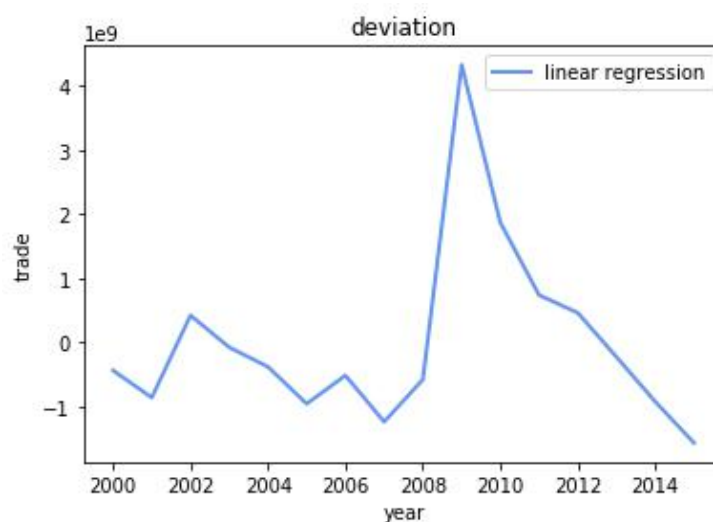


Figure 11. deviation of trade data (true and predicted)

But after 2016, the linear character disappeared. That's probably because Trump won the element in 2016, and with his sharp policy to China, this relationship began to be more and more uncertainty. In 2019, the Trade War between China and US began, and in this year, the trade between two countries dropped sharply.

If Trump still insist on punishing China by economy and tariffs, both two countries will be hurt and there will cause bigger undulate and more uncertainty. Biden's policy is similar to Obama's, if Biden is the president, he may stop this trade war and adjust the tariff rate. After a short time, the relation between tariffs and trade may come back to linear model like equation (11). Let's assume that after Biden chosen to be president a year, the relation is still equation(11). we can clearly see that Q is positive correlate to R , which means that in this equation China and US are cooperation relation and will be "win-win" after a long time.

4.3 Suggestions about Question 3

If I am a member of China's Think Tank for Economic Development, for two cases(which one win the element) I'll give suggestions below:

If Trump win the element: He will continue his sharp policy to China and keep emphasizing "America first ", restoring America's position in global diplomacy, reshaping American military power and allowing allies to bear more defense costs. According to Question 2, the relationship between tariffs and trade will be more and more uncertain. That require us to prepare for the challenge. If Trump still let COVID-19 spread, we need strict control of U.S. tourists and commodities to China, and strict vaccination tests, because once the infected people increase in China, the employment will be seriously affected according to equation(2). And with Trump's measure for COVID-19, the economy of US will be sharply affected. To deflect contradictions and stimulate the economy, Trump will continue to impose sanctions on China and may continue to raise tariffs. From Question 2 we find that with the wave of US's tariffs get bigger, the wave of trade is getting bigger too. Obviously, the trade of the two country will sharply decrease. On one hand China need to keep current not making situation worse and actively discuss with the US, on the other hand China should find a new trade partner more friendly and strong enough, to build up a long-term and stable cooperation relationship.

If Biden win the element: He will change many current situations. First, he will take anti-COVID-19 measure positively. This is not only beneficial for health safety every people in US, but help solve a big problem in the world. If the COVID-19 problem is solved, economy will come to rise all around the world. And secondly, he suggests to use more renewable energy, that will make economy increase. Thirdly, although he is opposed to lessen taxes, he advocate to raise the minimum wage of workers so the number of labor force will be larger to lessen the rising unemployment rate this year, even makes the labor force more than it was used to be. And the taxes will be used as capital input, both may excite economy. And most importantly, Biden's policy may ease tensions between China and the United States and finally finish the Trade War for a time. After the Trade War finished, the trade and tariffs will com back to a model like equation (11). we can clearly see the relationship between tariffs and trade. So China should find cooperation with US positively, and Actively promote the normalization of China-US diplomacy. And in equation (6), if technology is seen as a variable, the development of technology will push the development of economy. Besides cooperation in economy, we can also learn high-techniques in the US to push our economy development. In equation(9), $\alpha+\beta>1$, which means the increasing returns to scale indicate that it is beneficial to increase output by expanding production scale according to the existing technology. Industries in US want more labor but the labor force in US may be not enough, then we can try to attract US companies' investment in China. Economy of both countries will benefit from these a series of policies.

5. Strength and Weaknesses

5.1 Strength

1. Our model is based on economic theories, the method is reliable with previous tests.
2. Our data are all collected in official networks such as world bank. It's reliable and new, and can truly reflect the true information.
3. We use linear regression as our key tool to fit related data and establish model, very simple in whole process but R^2 score is high which means the model is suitable.

5.2 Weaknesses

1. It seems that we haven't take enough factors into consideration.
2. We discuss each factor separately. In fact, there are connections between variable and variable. For example, the COVID-19 will also infect the number of labor force, and they both influent GDP. So, if we take the two factors into one equation, or analysis their effects of level of association on GDP the result might be more accurate.

References

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【2】 Song Yanan. Research on the impact of foreign labor on Macao's economic growth -- from the perspective of industry [J]. International economic and trade exploration, 2013, 29 (003): 72-79

Appendix

Using tools: anaconda 3.7 (main coding and linear regression), MATLAB 2017a(help draw figures)

Python codes

Code1 :in Question 1 analysis $f(t)$, $g(t)$ and $r(t)$

```
import numpy as np
import pandas as pd

from sklearn.linear_model import LinearRegression,Ridge
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score

#before 2016
X=[[1,3],
   [1,4],
   [1,5],
   [1,6],
   [1,7],
   [1,8],
   [1,9],
   [1,10],
   [1,11]
  ]
y=[18.4183,109.2656,182.2117,269.5685,465.5611,617.7207,741.3600,933.6073,1319.7307]

lr=LinearRegression()
lr.fit(X,y)
y_lr=lr.predict(X)
print("the score of linear regression is")
print(f'mean squared error is: {mean_squared_error(y,y_lr)}')
print(f'mean absolute error is: {mean_absolute_error(y,y_lr)}')
print(f'R Squared is: {r2_score(y,y_lr)}\n')
```

```
print(lr.coef_,lr.intercept_)
import matplotlib.pyplot as plt
x=range(3,12,1)
x=np.array(x)
plt.figure()
plt.scatter(x, y, s=20, edgecolor="black", c="darkorange", label="data")
plt.plot(x, y_lr, color="cornflowerblue", label="linear regression", linewidth=2)
plt.xlabel("month")
plt.ylabel("people")
plt.title("true or predict")
plt.legend()
plt.show()
```

Code2: Fitting our COVID-19 model

```
import numpy as np
import matplotlib.pyplot as plt

from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
from scipy.optimize import curve_fit#用 python 拟合函数最主要模块就是 cure_fit
X=[[3,4,5,6,7,8,9],[18.4183,109.2656,182.2117,26.95685,465.5611,617.7207,741.3600]]
y=[100-7.67,100-8.54,100-10.46,100-11.23,100-12.99,100-14.44,100-4.53]
y=sorted(y,reverse=True)
X=np.array(X)
y=np.array(y)
four=[4,4,4,4,4,4,4]

def relu(x):
    L=[]
```

```
    for i in x:
        if i<=0:
            L.append(0)
        else:
            L.append(i)
    return L
f0=96.3883
'''
def f(X,r0,alpha,beta):
    return f0*(1/(1+r0*X[1])+alpha*X[0]+beta)
'''

def f(X,r0,alpha,beta):
    return f0*(1/(1+r0*X[1])+alpha*relu(X[0]-4)**beta)

popt,pcov=curve_fit(f,X,y)
print(popt)
r0=popt[0]
alpha=popt[1]
beta=popt[2]
print(pcov)
yval=f(X,r0,alpha,beta)#拟合完参数之后 就用拟合之后的参数来计算函数的值，
即得到拟合拟合曲线的数值
x=range(3,10)
```

```
plt.scatter(x,y)#原始数据画图

plt.plot(x,yval,'g',label='r0=%5.3f,alpha=%5.3f,beta=%5.3f'%tuple(popt))#拟合之后的数据画图 tuple 是把列表变成元组

plt.legend()

plt.show()

print(f'mean squared error is: {mean_squared_error(y,yval)}')

print(f'R Squared is: {r2_score(y,yval)}\n')
```

Code3: Cobb-Douglas function fit

```
import numpy as np
import pandas as pd
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score

df=pd.read_excel("question1-labour.xlsx")
X=df[['x1','x2']]
y=df.y

lr=LinearRegression()
lr.fit(X,y)
y_lr=lr.predict(X)
print("the score of linear regression is")
print(f'mean squared error is: {mean_squared_error(y,y_lr)}')
print(f'mean absolute error is: {mean_absolute_error(y,y_lr)}')
print(f'R Squared is: {r2_score(y,y_lr)}\n')
```

```
print(lr.coef_,lr.intercept_)

import matplotlib.pyplot as plt
x=range(2000,2019,1)
x=np.array(x)
plt.figure()
plt.scatter(x, y, s=20, edgecolor="black", c="darkorange", label="data")
plt.plot(x, y_lr, color="cornflowerblue", label="linear regression", linewidth=2)
plt.xlabel("year")
plt.ylabel("gdp")
plt.title("true or predict")
plt.legend()
plt.show()

#绘制偏差图像
plt.figure()
plt.plot(x, y_lr-y, color="cornflowerblue", label="linear regression", linewidth=2)
#plt.xticks(x_axis)
plt.xlabel("year")
plt.ylabel("gdp")
plt.title("deviation")
plt.legend()
plt.show()
```

Code4. energy and GDP

```
import numpy as np
import pandas as pd
from sklearn.linear_model import LinearRegression,Ridge
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
```

```
df=pd.read_excel("question1-energy.xlsx",sheet_name='Sheet2')

#X=np.array([5.42962369,4.67857121,4.84077918,5.32628227,5.47765652,5.841090
87,6.39651397,6.3041282,6.84554084,7.35440475,7.50517206,8.16445165,8.481450
41,8.71326157,8.75430895,8.71693587])

y=df.gdp

X=df[['cons','energy']]

lr=LinearRegression()

Lr=Ridge()

lr.fit(X,y)

Lr.fit(X,y)

y_lr=lr.predict(X)

y_Lr=Lr.predict(X)

print("the score of linear regression is")

print(f'mean squared error is: {mean_squared_error(y,y_lr)}')

print(f'mean absolute error is: {mean_absolute_error(y,y_lr)}')

print(f'R Squared is: {r2_score(y,y_lr)}\n')


print(Lr.coef_,Lr.intercept_)

print("the score of linear regression is")

print(f'mean squared error is: {mean_squared_error(y,y_Lr)}')

print(f'mean absolute error is: {mean_absolute_error(y,y_Lr)}')

print(f'R Squared is: {r2_score(y,y_Lr)}\n')


print(Lr.coef_,Lr.intercept_)


import matplotlib.pyplot as plt

x=range(2000,2016,1)

x=np.array(x)
```



```
plt.figure()
plt.scatter(x, y, s=20, edgecolor="black", c="darkorange", label="data")
plt.plot(x, y_lr, color="cornflowerblue", label="linear regression", linewidth=2)
plt.xlabel("year")
plt.ylabel("gdp")
plt.title("true or predict")
plt.legend()
plt.show()

#绘制偏差图像
plt.figure()
plt.plot(x, y_lr-y, color="cornflowerblue", label="linear regression", linewidth=2)
#plt.xticks(x_axis)
plt.xlabel("year")
plt.ylabel("gdp")
plt.title("deviation")
plt.legend()
plt.show()
```

Code5. trade and tariffs

```
import numpy as np
import pandas as pd
from sklearn.linear_model import LinearRegression,Ridge
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score
#before 2016
X=[[1,745],
   [1,805],
   [1,972],
   [1,1263],
   [1,1696],
```

```
[1,2116],  
[1,2627],  
[1,3021],  
[1,3337],  
[1,2983],  
[1,3853],  
[1,4467],  
[1,4847],  
[1,5210],  
[1,5551.2],  
[1,5583.9]  
]  
y=[20000000000,  
20636000000,  
19938000000,  
21458100000,  
23282900000,  
25334900000,  
26687000000,  
28793000000,  
29243100000,  
23081000000,  
28603000000,  
31891000000,  
33503000000,  
35468000000,  
37363100000,  
38123000000  
]
```

```
lr=LinearRegression()
lr.fit(X,y)
y_lr=lr.predict(X)
print("the score of linear regression is")
print(f'mean squared error is: {mean_squared_error(y,y_lr)}')
print(f'mean absolute error is: {mean_absolute_error(y,y_lr)}')
print(f'R Squared is: {r2_score(y,y_lr)}\n')

print(lr.coef_,lr.intercept_)
import matplotlib.pyplot as plt
x=range(2000,2016,1)
x=np.array(x)
plt.figure()
plt.scatter(x, y, s=20, edgecolor="black", c="darkorange", label="data")
plt.plot(x, y_lr, color="cornflowerblue", label="linear regression", linewidth=2)
plt.xlabel("year")
plt.ylabel("trade")
plt.title("true or predict")
plt.legend()
plt.show()

#绘制偏差图像
plt.figure()
plt.plot(x, y_lr-y, color="cornflowerblue", label="linear regression", linewidth=2)
#plt.xticks(x_axis)
plt.xlabel("year")
plt.ylabel("trade")
plt.title("deviation")
plt.legend()
```

```
plt.show()
```

Matlab codes

After read excel files, we give variables names and then plot some figures with commands below:

```
plot(years,gdp);hold on;xlabel('years');ylabel('GDP(dollars)');title('GDP of US these years');  
plot(years,tariffs);hold on;xlabel('year');ylabel('tariffs(dollars)');title('total tariffs of US');  
plot(years,trade);hold on;xlabel('year');ylabel('trade(million dollars)');title('the total trade  
between China and US during 2000-2019');  
bar(year,input,'r');hold on;bar(year,output,'y');hold on;  
Y=[input,output,total,delta];bar(year,Y,'grouped');hold on;  
xlabel('years');ylabel('million dollars');legend('export from China to America','import of  
China','total trade','difference between China and America');  
legend('Total trade','Chinese imports to the United States','Chinese exports to the United  
States','trade surplus');
```