Research on the Relationship between Unemployment Rate and Vaccination Rate in United States

Fangyuan Hu, Jingyu Pang, and Haotian Sun

Abstract—**The outbreak of the new crown pneumonia epidemic in 2019 has had a huge impact on the economy and social employment. Since 2021, the unemployment rate has continued to decline in the United States. Research on the relationship between the unemployment rate and the vaccination rate has received extensive attention from more and more scholars. This article aims to clarify the relationship between unemployment rate and vaccination rate through the collected data. By constructing limited distribution lag model to examine the relationship between vaccination rate and education level on unemployment rate in each state in the United States, it is found that the increase in vaccination rate will indeed reduce the unemployment rate. Vigorous promotion of vaccination is a benefit to achieve the stability of the US labor market. In addition, the research in this article also found that the level of education also has an impact on the vaccination rate and unemployment rate. The higher the level of education, the higher the vaccination rate and the lower the unemployment rate. This shows that the epidemic may exacerbate the gap between the rich and the poor and racial inequality in American, and the government needs to pay attention to the disadvantaged groups.**

Index Terms—**Unemployment rate, vaccination rate, limited distribution lag model, Covid-19.**

I. INTRODUCTION

A. Research Background and Motivation

After the peak of unemployment rate in 2020, the unemployment rate in the United States has been declining steadily in 2021, but it has not fully recovered to the level before the epidemic. To date (October 2021), the national Covid-19 vaccination rate in the United States has not yet reached 60%, which is still far from the desired rate. We hope to use this paper to confirm whether vaccination rates are effective in reducing unemployment and to examine the potential factors behind vaccination rates that influence unemployment rates.

B. Literature Review

Some researchers believe that the increase of vaccination rate can help to decrease the unemployment rate, the team of a new analysis by the Penn Wharton Budget Model at the University of Pennsylvania shown that doubling vaccination rate could spark employment and boost GDP by analysing the data of the general nation [1]. On the contrary, some researchers like Roghani studies the data in every state and hold the opinion that unemployment and vaccination rate had a positive linear association [2].

C. Research Contents and Framework

This article aims to clarify the relationship between the unemployment rate and the vaccination rate through the data we have collected. Unlike previous studies, our study will consider the general country and the entire country to obtain more comprehensive results. We will also consider other factors that may affect the unemployment rate, especially the level of education, and analysis its relationship with the vaccination rate. The research framework of this article is arranged as follows. The first part is the introduction, which mainly introduces the research background and motivation of this article as well as the literature review. The second part is the methodology and model construction, the third part is the results and discussion, and finally the conclusion.

II. MODEL SETTING

Due to the mechanism of Covid-19 vaccine, people need to receive two doses of the vaccine to be effective. This article uses the percentage of people who have received at least one dose of the Covid-19 vaccine as the vaccination rate in the jurisdiction where residents live, since people would usually receive a second dose after the first dose. Meanwhile, two doses of vaccine must be given at least 20 days apart. This is the reason why we adopt the limited distribution lag modal to study the relationship between domestic vaccination rate and unemployment rate. This paper discusses the situation of 51 states. Besides studying the relationship between vaccination rate and unemployment rate of individual states, the paper also introduces the multiple linear regression model including high school education, bachelor's degree and above, and the vaccination rate, since education level greatly influences unemployment rate and people's attitude towards vaccination [3]-[5].

III. EMPIRICAL ANALYSIS

A. The Study of Domestic Vaccination Rate and Unemployment Rate

This article uses a simple linear regression model to examine the relationship between the monthly vaccination rate and the unemployment rate in the United States from February to November 2021 [6], [7]. The expression of the model is,

$$\log(\widehat{unem_t}) = \widehat{\beta_0} + \widehat{\beta_1} vax_t \tag{1}$$

Here, $unem_t$ represents unemployment rate of one certain month, vax_t represents the vaccination rate of that month, and vax_{t-1} represents the vaccination rate of the previous month.

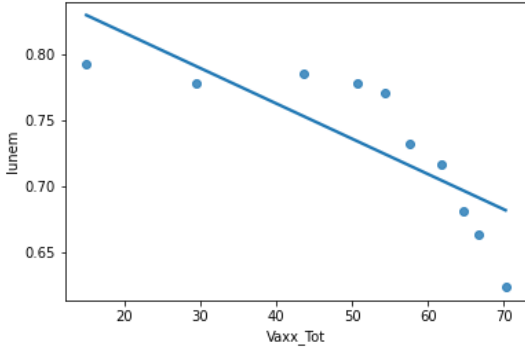This paper receive Fig. 1 according to the data from CDC and U.S. Bureau of Labor Statistics.

Fig. 1. Scatter plot of domestic vaccination rate of current month, and domestic unemployment rate.

As can be seen from Fig. 1, $\widehat{\beta_0} = 0.8701$, $\widehat{\delta_1} = -0.0027$ from model, which indicate negative effect from vax_t to $unem_t$. Our results suggest that the introduction of vaccination policies in the United States has indeed reduced unemployment throughout the country.

B. The Study of Vaccination Rate and Unemployment Rate of Each State

Besides domestic rates, this paper analyzes the impact of vaccination rate on unemployment rate in different states. By ordinary least squares analysis of the natural logarithm of the unemployment rate for 51 states in September 2021, and the (at least one dose) vaccination rate of that month,

$$\log(\widehat{unem}) = \widehat{\beta_0} + \widehat{\beta_1} vax \tag{2}$$

Here, $unem$ represents the unemployment rate of one certain state in September 21, and vax represents the vaccination rate in the same month of that state [6], [8].
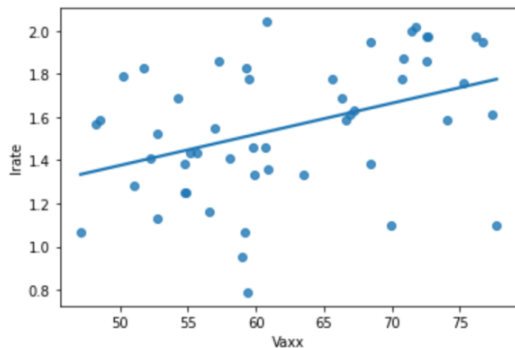

Fig. 2. Scatter plot of vaccination rate and $\log(unem)$.

Through calculation, this paper concludes that there is a positive correlation between vaccination rate and unemployment rate. When the vaccination rate increases by 1%, the unemployment rate will increase by 1.44% on average. This is clearly counter intuitive: why does

unemployment rise when people are vaccinated against the epidemic? In fact, those states with high unemployment rates in September 2021 already had relatively high unemployment rates prior to the outbreak and at the beginning of the outbreak, as shown in the following Table I [6]-[9].

TABLE I: UNEMPLOYMENT RATE AND VACCINATION RATE

State	Unemployment Rate				% Vax
	Feb-20	Feb-21	Sep-21	% Change	
AL	7.1	4	3.1	0.9	52.7
AK	7.2	6.6	6.4	0.2	57.3
AZ	7	6.9	6.2	0.7	59.3
AR	6.5	4.5	4.2	0.3	55.7
CA	12.3	8.5	7.5	1	71.7
CO	7.1	6.6	5.9	0.7	65.6
CT	8.4	8.5	7.2	1.3	76.2
DE	7.9	6.3	5.4	0.9	66.3
DC	8.8	8.1	6.5	1.6	70.8
FL	7.9	4.7	5	-0.3	66.9
GA	7	4.8	3.5	1.3	54.9
HI	14.1	9.2	7	2.2	76.7
ID	4.9	3.3	2.9	0.4	47.1
IL	11.1	7.4	7	0.4	68.4
IN	7.3	4	4.1	-0.1	52.2
IA	5.3	3.6	4.1	-0.5	58.1
KS	6.2	3.2	3.8	-0.6	59.9
KY	5.5	5.2	4.3	0.9	60.7
LA	8.2	7.6	6.2	1.4	51.7
ME	5.2	4.8	4.9	-0.1	74.1
MD	8.6	6.2	5.9	0.3	70.7
MA	9.3	7.1	5	2.1	77.4
MI	8.5	5.2	4.7	0.5	57
MN	6.6	4.3	3.8	0.5	63.5
MS	7.8	6.3	6	0.3	50.2
MO	6	4.2	4	0.2	54.8
MT	5.8	3.9	3.5	0.4	54.8
NE	4	3.1	2.2	0.9	59.4
NV	14.5	8.3	7.7	0.6	60.8
NH	6.6	3.3	3	0.3	69.9
NJ	11	7.8	7.2	0.6	72.5
NM	9.3	8.3	7.2	1.1	72.6
NY	11.7	8.9	7.4	1.5	71.4
NC	6.8	5.7	4.3	1.4	59.8
ND	6.1	4.7	3.6	1.1	51
OH	9	5	5.4	-0.4	54.2
OK	6.3	4.4	3.2	1.2	56.6
OR	8.4	6.1	4.9	1.2	66.6
PA	10.2	7.3	6.4	0.9	72.5
RI	12.6	7.3	5.8	1.5	75.3
SC	5.4	5.2	4.2	1	55.2
SD	4.7	2.9	2.9	0	59.2
TN	8.1	4.9	4.6	0.3	52.7
TX	6.9	6.9	5.9	1	59.5
UT	4.8	3	2.6	0.4	59

VT	5.4	3.1	3	0.1	77.7
VA	7	5.2	4	1.2	68.4
WA	9.1	5.6	5.1	0.5	67.2
WV	8.5	6.2	4.8	1.4	48.2
WI	6.1	3.8	3.9	-0.1	60.9
WY	6.2	5.3	4.9	0.4	48.5

If we re-run the ordinary least squares analysis of the amount of change in unemployment from February to September and vaccination rate for each state. The results are shown in Fig. 3.
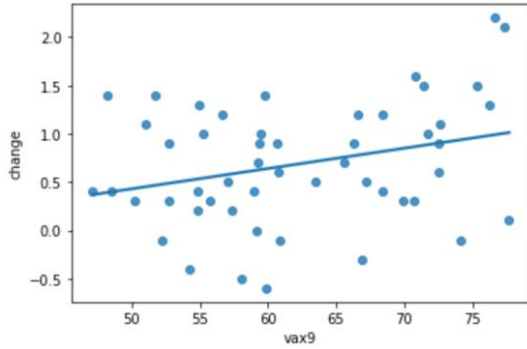

Fig. 3. Scatter plot of Sep 2021 vaccination rate and change in unemployment from Feb 2021 to Sep 2021.

This time we still get a positive correlation, but this positive correlation means that if a state has a higher vaccination rate($vax9$)in September, then it will have a greater decrease($change$)in unemployment. This result tells us that higher vaccination rates do contribute to lower unemployment rates. Also, this is the same result we obtained in our initial analysis of the U.S. national data.

C. The Further Study of Unemployment Rate

The previous models used in this paper only discusses the single linear relationship between vaccination rates and unemployment rates. Concerned about the bias of omitted variables, we need to consider the effect of other variables on the unemployment rate. At this point, it is inevitable that we do not think about the effect of education level on the unemployment rate [3], [4]. Generally, people with higher levels of education are less likely to be unemployed for long periods of time, and education level does affect one's knowledge of vaccines. We begin by modeling,

$$\log(\widehat{change}) = \widehat{\beta_0} + \widehat{\beta_1}vax + \widehat{\beta_2}hs + \widehat{\beta_3}co \qquad (3)$$
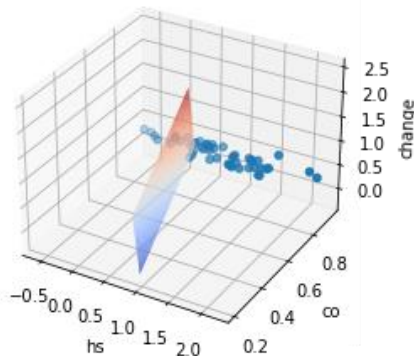

Fig. 4. Scatter plot of unemployment rate of Sep 2021, high school rate, and college rate of each state.

Here, $change$ represents the amount of decrease in unemployment in a state from February to September 2021, vax represents the vaccination rate in September 2021 of the state, hs represents the percentage of people with a high school diploma in this state, and co represents the percentage of people in the state with a bachelor's degree or higher. The paper observed educational data from U.S. Census [10].

Nevertheless, after establishing the multiple linear regression model while taking vax, hs, and co into consideration, this article found out that the partial effect of vax on $\widehat{change}$ is relatively small, which indicates that we cannot save the variable in our model. After adjustment.

Here, $\widehat{\beta_2} = -10.7464$, $\widehat{\beta_3} = 4.1722$. This means that having only a high school degree may put people at a great disadvantage in the labor market during the epidemic. At this point, let us analyze the relationship between vaccination rates and college degrees.
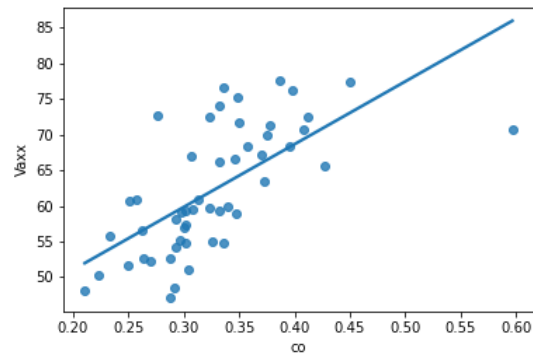

Fig. 5. Scatter plot of Sep 2021 vaccination rate and college degree rate of each state.

Here, we obtain a strong positive correlation, which means that if the level of education of people in a state is higher, then the vaccination rate in that state is higher. Relating this to our previous SLR model on vaccination rates and unemployment rates, we will find that the effect of vaccination rates on unemployment rates is most likely due to education levels. On the one hand, if people in a state have a higher level of education, then the more likely these people are to take effective approaches to ease the negative effects of the epidemic. On the other hand, people with higher levels of education tend to be able to find stable jobs more easily, while at the same time, they can be more flexible in their employment choices.

IV. DISCUSSION

A. Education Level and Unemployment Rate

Model in 3.3 indicates that higher level of state vaccination rate is related to higher level of education, which may help decrease unemployment rate. There are also existing study indicates the positive correlation between education level and vaccination rate [11]. This is because people of higher education level may understand the mechanism of vaccination against Covid-19 virus better, and they may come up with better policies to help eliminate unemployment level. According to the article by Scott A. Brave and Stephanie Grove, for those industries that are difficult to work from home (with low educational requirements), an

increase in vaccination rates can help their employment recovery [12]. At the same time, the impact of vaccination rates on employment in industries such as financial services, which require a high level of education but can work from home, was minimal, but this does not contradict the point of this paper. According to current employment statistics released by the U.S. Bureau of Labor Statistics, the Covid-19 pandemic has no negative effect on employment in the financial services industry. In contrast, mean "approximately" or "effectively." Do not use the word "issue" as a euphemism f the epidemic had a very serious negative impact on those industries that require less education. All of these observations are consistent with the findings of this paper.

B. The Abnormal Positive Correlation between State Unemployment Rate and Vaccination Rate

This paper analysis the condition in every state, using ordinary least squares analysis model, we get that vaccination rates (at least one shot) in 51 states and unemployment rates has positive relationship, just like some research said. However, later, this paper found out those states with high unemployment rate in September 2021 have relatively high unemployment rate even before and at the beginning of the epidemic, so we can't get the conclusion that the high vaccination rates exaggerate the unemployment. And to eliminate this factor, we should compare what change the vaccination rate brought, so we reanalysed the change of unemployment rate from February to September and the vaccination rate in September by ordinary least square method, and get the result that if a state has a higher vaccination rate in September, the more its unemployment rate will change, which means a higher vaccination rate is indeed conducive to reducing the unemployment rate. In summary, no matter in the general nation or in every state, the vaccination rate can mitigate the unemployment rate.

V. CONCLUSION

At present, the state with the lowest unemployment rate in the United States is New Hampshire, with an unemployment rate of 2.5%; The state with the highest unemployment rate is Hawaii, with an unemployment rate of 8.1%. From the perspective of vaccination, most of the states or regions that have achieved the goal of 70% vaccination rate are in the northeast and the Atlantic, such as Pennsylvania, Vermont, Massachusetts, New Jersey and California, while most of the states with low vaccination rate are in the south, such as Texas and Mississippi. Whether the vaccination rate will have a different impact on the job market in each state has become the topic of our article.

This paper discusses the mechanism of the impact of the vaccination rate on the unemployment rate in the United States, and constructs a time series model with the vaccination rate and its lag value as the explanatory variable and the unemployment rate as the explanatory variable, The results show that the current vaccination rate and the delayed vaccination rate have a negative impact on the unemployment rate, which shows that the vaccination policy of the United States can indeed reduce its unemployment rate. Specifically, the current vaccination rate has increased by 1%

and the current unemployment rate decreased by 0.09%. The vaccination rate in the previous period increased by 1%, and the unemployment rate in this period decreased by 0.11%. Further, we also studied the impact of vaccination rates on unemployment in different states. By constructing the scatter diagram of unemployment rate and vaccination rate in 51 States, we find that there is a positive correlation between them, which is contrary to the above conclusion. Therefore, we carefully analyzed the panel data and found that those states with high unemployment rate had high unemployment rate before and at the beginning of the epidemic. If we take the change of unemployment rate in each state after the outbreak of the epidemic as the explanatory variable, we find that our previous conclusion is still valid, that is, the higher the vaccination rate, the lower the unemployment rate. Finally, our previous model does not take into account the problem of control variables, which makes us worry about the possible missing variables in the model. Therefore, we added the education level of each state as the control variable in the model, because generally speaking, the education level has an impact on people's understanding of vaccines and career probability. The results showed that there was a strong positive correlation between education level and vaccination rate. Among them, the difference in vaccination rates between the north and South states of the United States deserves attention. People in some southern states are hesitant about vaccination. On the one hand, this is related to the low level of local education, which leads to residents' insufficient understanding of the epidemic situation and fear of the rapid development of medical technology, which will put pressure on the unemployment rate in the southern states.

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