ERASMUS UNIVERSITY ROTTERDAM

Erasmus School of Economics

Bachelor Thesis: International Bachelor of Economics and Business Economics

The effects of COVID-19 and the restrictive measures on the macroeconomic factors; fixed-effects model approach

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Date final version: 27/10/2020

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Abstract

The paper assesses the effects of new corona patients on the two macroeconomic factors; unemployment rates and exchange rates. In addition to monthly new patients in the log form, different restrictive measures are included as explanatory variables in the fixed-effects model. In total, data on 17 countries for the period between August 2019 to August 2020 are used for the panel data analysis. We have found the correlation between the first lag of monthly corona patients and the unemployment rates, but the effect was statistically insignificant. The effect of restrictive measures on the unemployment rates was negative but also insignificant.

Introduction

The latest world pandemic, COVID-19, damaged the economy of many developing and developed countries without borders. The first few countries that suffered from the outbreak of this virus in Asia are; China, Korea, and Japan. Because of this pandemic, they were forced to realize how their economy relied on international trade and in-person activities. China is one of the largest exporters in the world, where they cover the main proportion of the imported goods in Korea and Japan. China already experienced negative GDP growth of 6.8% in the first quarter. The situation continues to worsen in Japan as of 30 April even after four months since the first case was confirmed in January (Vaswani, 2020). Korea however, achieved a low number of patients since late-April, and emerged to recover from the recession faster than other G7 countries in October 2020 (Kim, 2020).

This pandemic has caused many of us to change our lifestyle or even plans for the coming few years. One of the main economic concerns people have is the effect of this virus on the unemployment rates, after hearing news reminding us that many companies, including ones that were doing completely fine in pre-corona periods, are running out of business in the past few months. The unemployment rates in different countries also depend on their economic conditions or governmental measures. Since the low unemployment rates is one of the primary objectives of governments, it is important to consider possible unfavorable effects on restrictive measures such as lockdown or the emergency statement. Besides, we look at the effect of coronavirus on exchange rate fluctuations. Both variables are crucial macroeconomic factors that reflect the performance of the economy.

For these reasons, *the effects of COVID-19 and restrictive measures on the macroeconomic factors* area investigated. Because this pandemic is still relatively new and continuing at this moment when I started writing the thesis, there are not many papers with quantitative approaches available on this topic. Investigating the effect of government reaction will be useful for policymakers dealing with COVID-19 and the following economic crisis, as it is expected that the situation continues at least for a year or longer before it is completely subsided. Understanding the relationship between coronavirus and the unemployment rates also provides us with some guidance to survive in the post-corona economy.

In this research, we first investigate the relationship between coronavirus and the unemployment rates using 17 mainly affected countries. The fixed-effects model is implemented to account for the country-specific variables and time-specific variables. In the second step, we look further into the effect of restrictive measures. In this paper, we analyze three Asian countries, namely; China, Korea, and Japan in more detail, though all measures in 17 affected countries are included in the model. The three countries took very different approaches to combat the virus, despite having relatively similar economic structure and economic conditions.

Some highly infected provinces in China such as Wuhan imposed a strict lock-down policy to suppress coronavirus, and if there is no political pressure to report fake news, they successfully achieved a near-zero count in April (Aydin, 2020). The credibility of news is still questionable, but if this is genuine, other countries can take Wuhan as a lesson and apply it to overcome this pandemic.

On the other hand, Japan did not impose a strict lockdown measure despite an increasing number of cases since the beginning of 2020. Criticism arose for the extremely slow reaction of the government both to suppress the virus and to ensure economic safety for those who have been affected. Even with the “Emergency declaration” which is enacted on 7 April 2020 in seven manly affected provinces, people continue to commute or go outside almost freely, as this declaration does not have any legal force to restrict the actions of their citizens (Ministry of Health, Labor and Welfare, 2020). It has been a problem that people gather at non-restricted areas such as beaches or outdoor shopping streets, creating a high-risk area. As expected, Japan is currently failing to suppress the virus, and the number continues to increase relatively slowly but surely.

Many companies, especially in the tourism and restaurant business, were forced to go out of business due to a decrease in demand, hence countries that heavily depend on these in-person businesses should be negatively affected by the number of corona patients in the country, as well as by the lockdown measure imposed by their governments.

The null hypothesis of the research is that there is no correlation between the number of COVID-19 cases in a country and its unemployment rates. We expect that when the cases in a country increases, people tend to be more conscious about social-distancing, and as a result, their economic activities such as going out for dinner or going on vacation decrease. The effect of the lockdown measure on unemployment rates could depend on the economic structure or consumer confidence, as well as the legal impact of the lockdown measure. Countries with strong legal force may be able to suppress the virus faster, however, in the meantime, the effect on the unemployment rates would be also negative and strong as people are forced to stay home.

In the rest of the paper, we first discuss COVID-19 situations in three nations; China, Korea, and Japan. Then, we explain the methodology and data used in the research in the next section. Finally, we summarize and discuss the findings of the research in two parts; first the effect of COVID-19 patients on the unemployment rates in 17 mainly affected countries, and then the effect of different measures in three above-mentioned countries. These measures are included in the form of dummy variables.

Theoretical Framework

COVID-19 is an infectious disease first confirmed in December 2019 in Wuhan and has spread globally causing the ongoing world pandemic. As of 23 April 2020, more than 2.62 million cases have been reported across 185 countries and territories, resulting in more than 183,000 deaths (WTO, 2020). About 30% of patients have recovered, but the cases are ongoingly increasing. In combination with the current anti-black racism movements, restricting movements of the people is getting more difficult, and so does suppressing the virus. Fernandes (2020) suggested that each additional month of crisis costs 2.5%-3% of global GDP. It is therefore crucial for the governments to suppress the virus as soon as possible or figure out ways to coexist with this virus by a drastic reform in the economic system.

In Asia, a total of 282 cases have been confirmed as of 20 January 2020 in four countries including China, Thailand, Japan, and Korea, where cases in three new countries are exported from Wuhan, China. At this point, coronavirus related cases were only confirmed in Asia. Hence, there were not yet any strict travel restrictions from Asia to Western countries, unless one has been to high-risk areas. Besides, there were already people coming from or returning from Wuhan to many countries including Japan and Korea before the confirmation of the first case, hence it was impossible to perfectly isolate citizens from infected people. Since then, COVID-19 has spread across Asia, which is explained in more detail below.

Situation in China

According to WHO, the first coronavirus patient was confirmed in Wuhan Seafood wholesale market on 30 December 2020. The number of infections exceeded over 40 shortly after, and on 7 January 2020, the officials announced that they have identified a new virus, COVID-19. On 16 January 2020, China announced its first death, a 61-year-old male who had purchased fish from the market.

Later in January, a Chinese expert confirmed human-to-human transmission of COVID-19 to state broadcaster CCTV, raising fears as millions traveled for the lunar new year. As of 23 January 2020, the cities of Wuhan, Xintao, and Chibi in Hubei province were placed under lockdown. By the end of the month, the lockdown area increased affecting a total of 56 million people. On 30 January 2020, the WHO announced the coronavirus “a global emergency” as the death toll jumped 170 with 7,771 cases reported in China.

As of 1 March 2020, a total number of 80,000 cases were confirmed in China, reaching its peak. After this, the number of new cases per day slowly decreased, and as of 27 April 2020, only 3 new patients are reported according to the world meter.

In the meantime, Chinese GDP has declined by 6.8% in the first quarter, causing millions of workers to lose their jobs. The demand for Chinese products drastically decreased due to COVID-19 fear, resulting in lower exports as well as imports. However, the government of China is struggling to activate any significant stimulus. As of January 2020, the total domestic

debt of China as a share of GDP reached 310%, making it difficult to open up its tab for the economy anymore (Wilson, 2020).

Situation in Japan

After the first case was confirmed on 15 January 2020, 16 cases were confirmed in January among people who visited Wuhan or had close contact with those who visited Wuhan earlier in January. The number of new cases seems relatively low during February not reaching any number higher than 2-digits per day, but after the announcement of the Tokyo Olympics being postponed, this number jumped up and now reaching 3-digits in April.

While many western countries have reached more cases and deaths confirmed in a short period, Japan took a different approach. Instead of the lockdown, the Japanese government has announced an emergency statement on 7 April 2020 in seven prefectures, and they extended the measure to other areas on 16 April 2020. Emergency statements can restrict group activities and meetings and many public facilities were closed temporarily; however, it does not have the legal power to control individuals' actions.

They have removed the emergency statement in all the prefectures after 25 May 2020, and all the businesses/schools are opening gradually. In the end, Japan was able to suppress the virus without any strict lockdown measures. One explanation of this is the pre-existing inclination of wearing masks and naturally keeping social distance unless physical contact is necessary. Japan does not have a culture of shaking hands or hugging, and the country is known as having a highly hygienic environment, which may have contributed to achieving low numbers of cases and deaths.

One skepticism of this trend is that the number of testing is also extremely low in Japan despite the WTO's advice "test, test, test". As of October 2020, Japan has conducted a total of 2,336,696 tests, while in Korea they have conducted 2,560,056 tests despite the Japanese population being more than two times larger than Korea (Ogiwara, 2020). Moreover, the number of patients spiked up in July and August in Japan after the lockdown, suggesting that wearing masks is not enough for suppressing the virus. Still, the number of death cases remains relatively low in Japan as of September 2020.

Situation in Korea

Korea imposed a much stricter quarantine policy for people who returned from abroad. They created an app called "Corona Map" which plots the routes that people confirmed to have COVID-19 have been, to make avoiding these locations easier (Huang et al, 2020). Detailed information about COVID-19 infected people is also disclosed on the government website, so citizens of Korea had access to much clear information about this pandemic compared to the rest of the world. It is also important to note that Korea conducted extensive testing in the early stage.

As of 24 April 2020, a total of 583,529 testing was conducted, whereas Japan only conducted a total of 117,367 testing by the same date (WTO, 2020 & Ogiwara, 2020). Since there are many cases where COVID-19 patients only have mild or no symptoms at all, testing as many as possible seems to be a reasonable approach. Many countries are hesitant to take this approach as they are afraid of the collapse of the healthcare system. As a result of this strict measure, Korea was able to suppress COVID-19 cases much faster than Japan. The number of new cases continued to decline since 30 March 2020, and as of 24 April, only 10 new cases were confirmed.

On 30 January 2020, the President of Korea, Moon Jae-in announced a cash payment of 1 million won (about €800) to all households except for the top 30% income earners. There is also another financial stimulus added to the package in Korea, but in this research, I focused on this direct cash payment.

Literature review

Coronavirus already had a severe impact on employment in numerous countries. According to UK survey data collected on 23 March 2020, 8% of workers in employment already lost their job due to COVID-19 (Adams-Prassl, 2020). The young, and low-income workers have been hit hardest, and many of them are expected to have trouble paying the bills. The outbreak is creating spillover effects throughout supply chains, and therefore the recovery of the economies would take much longer than initially expected (Fernandes, 2020).

Dormidos and Leung (2020) argue that unless governments take immediate action to curtail the virus within the shortest period possible, China will lose up to 62 billion in the first quarter

of the year, while the world is expected to lose up to 280 billion in the same period. According to Furuoka (2014), Korea exhibits a stationary process, while China and Japan are already experiencing rather unstable rates in pre-corona periods due to different factors such as differences in unemployment benefits, differences in available resources, and education. The current pandemic certainly has impacts on all of these factors, hence unemployment rates in the post corona periods are expected to deviate from the natural rates. Many other researchers have already found that most economies are going to experience long and severe recessions in the coming years, but there are not many empirical tests conducted on this topic due to the lack of data available at the moment.

In our research, panel data is implemented to analyze the effect of COVID-19 patients and the unemployment rates. Like time-series data, panel data are collected chronologically. Just like cross-sectional data, panel data contains observations across different groups of individuals, more specifically, countries. Panel data minimizes biases that pure time-series data or cross-sectional data fail to capture.

This approach is implemented by Andreas (2005) to investigate the relationship between unemployment rates and suicide rates. He argues that previous studies neglected the use of country-specific time-trend, which may cofound the empirical estimate of socio-economic variables due to time-varying unobserved country-specific factors. For that reason, time-fixed effects and country-fixed effects are used in the model.

Methodology

To look at the total effect of COVID-19 and different measures, we divide the test into two steps. First, the effect of new COVID-19 patients on the fluctuation of unemployment rates is tested for 17 countries using fixed effect model analysis. The simplified fixed effect model is as follows;

$$U_{i,t} = c_t + a_i + \beta_1 * COVID_{i,t-1} + e_{i,t} \quad (1)$$

where $U_{i,t}$ is the unemployment rates of each country at time t in months, c_t captures time-specific fixed effects at time t, a_i capture country-specific effects, $COVID_{i,t-1}$ is the natural log of the number of COVID-19 patients of each country at t-1, and lastly $e_{i,t}$ is the disturbance term that varies across countries and over time. Our independent variable, $COVID_{i,t-1}$ is 1st lagged because markets would take time for the adjustments to reflect on the number of patients. For instance, it takes time for employers to laid-off workers due to contracts.

An individual fixed model is better able to capture and account for differences across countries than OLS models. According to Vartanian and Buck (2005), having a different constant value for each group provides a control for those factors that are permanent features of groups but are not explicitly examined in the model. Thus, an individual fixed model can solve the omitted variable biases as long as those unobserved variables are constant over time. Since we are interested in the unemployment rate fluctuations, we will subtract the equation (1) at t-1 from the equation (1) at time t. The individual fixed effect model is then as follows;

$$U_{i,t} - U_{i,t-1} = (c_t - c_{t-1}) + (a_i - a_i) + \beta_1 * (COVID_{i,t-1} - COVID_{i,t-2}) + (e_{i,t} - e_{i,t-1}) \quad \dots (2)$$

$$U_{i,t} - U_{i,t-1} = (c_t - c_{t-1}) + \beta_1 * (COVID_{i,t-1} - COVID_{i,t-2}) + (e_{i,t} - e_{i,t-1}) \quad \dots (3)$$

where $U_{i,t} - U_{i,t-1}$ shows unemployment rate fluctuations, $c_t - c_{t-1}$ indicates change in the time-specific fixed effects, country-specific effects a_i is canceled out since the equation (1) is estimated in differences, $COVID_{i,t-1} - COVID_{i,t-2}$ shows the growth rates of monthly corona patients, and finally $e_{i,t} - e_{i,t-1}$ shows the error term that captures time-varying factors. Time-varying unobserved variables such as the number of travelers coming into the country and the number of people wearing masks still need to be concerned but not individually captured in the

model. These are captured in the error term as the total effects of unobserved time-varying factors. The dataset used in the model only contains the information about the number of COVID-19 patients and the unemployment rates. It lacks information about possible factors that affect unemployment rate values, such as trade volumes or more detailed population data. Accordingly, we must be cautious about this limitation in interpreting the results from this fixed-effects model.

In the second step, the effects of restrictive measures on unemployment rate fluctuations for each country are included in the model as dummy variables. These factors are added on top of the fixed-effects model (3), as follows;

$$U_{i,t} - U_{i,t-1} = (c_t - c_{t-1}) + \beta_1 * (COVID_{i,t-1} - COVID_{i,t-2}) + \beta_2 * (FS_{i,t-1} - FS_{i,t-2}) + (e_{i,t} - e_{i,t-1}) \dots (4)$$

where $FS_{i,t-1}$ indicates a dummy variable for the restrictive measures, which takes the value 1 when the measures are active, and otherwise 0. *FS* are also included as lagged values for the same reason as variable *COVID*. We used lagged values for *FS* since it takes time for individual companies to change their employment situations. The empirical result of the effect of restrictive measures contributes to understanding the effectiveness of government intervention in the time of the world pandemic.

In addition to the unemployment rate fluctuations, we investigate the effect of coronavirus on the exchange rates. The exchange rate is one of the important macroeconomic factors which shows the performance of the economy. Especially for countries which their GDP is mainly composed of international trade, exchange rate fluctuation is often undesirable, because both investors and consumers prefer stable currency rate. We used 11 different countries during the period between July 2019 to September 2020, by week. The fixed-effects model for the exchange rate fluctuations is as follows;

$$E_{i,t} - E_{i,t-1} = (c_t - c_{t-1}) + \beta_1 * (WEEKCOVID_{i,t-1} - WEEKCOVID_{i,t-2}) + (e_{i,t} - e_{i,t-1}) \dots (5)$$

where $E_{i,t} - E_{i,t-1}$ is the change in the exchange rates in log form, $c_t - c_{t-1}$ captures time-fixed effects, $WEEKCOVID_{i,t-1} - WEEKCOVID_{i,t-2}$ is weekly new patients in log form, and finally $e_{i,t} - e_{i,t-1}$ absorbs disturbances.

Data

The number of daily coronavirus patients is taken from the WHO database. We have gathered data for 17 mainly affected countries, which is listed in the table below. The data is collected for the period between August 2019 to August 2020. We have then manually calculated monthly patients using the daily data. Then the data is converted into a natural log form before taking the difference, because we are interested in the percentage difference rather than the absolute change in the number of patients.

Data on unemployment rate is taken from Short-Term Labor Market Statistics: *Monthly Unemployment Rates* published by OECD. We have then calculated changes in the unemployment rate by taking the log of difference. Information on different measures is retrieved from the BBC, NHK, NIKKEI, and WHO reports. Lastly, data on the exchange rates are retrieved from the IMF exchange rate report. A total of 11 currencies are used in the analysis, where the rates show the prices of one unit of USD in respective currencies.

Descriptive Statistics

In this section, we explain the descriptive statistics of the panel data. To begin with, we mainly use three variables in the research: unemployment rates, monthly COVID patients, and restrictive measures. We first look at the mean of these variables over months to see whether data is uniformly distributed.

Let us now look at the unemployment rate fluctuations over the months. The bar chart below shows the monthly average of the unemployment rate:

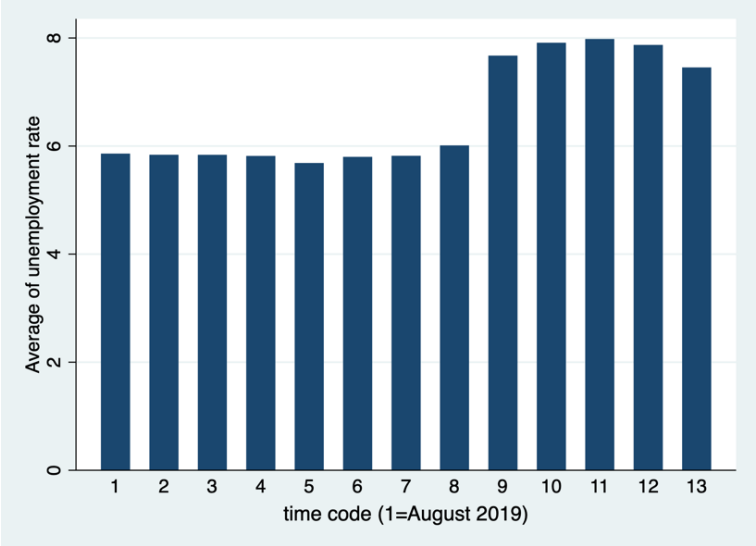

Figure 1: Average unemployment rate per month

The x-axis shows the month in numeric numbers (1= August 2019), and the y-axis indicates the average unemployment rates. 17 countries included in the analysis are; Australia, Canada, Italy, Japan, Brazil, China, Finland, France, Denmark, Columbia, The Netherlands, Norway, Mexico, South Korea, Sweden, United States, and United Kingdom. It could be seen from Figure 1 that the rates are relatively stable at about 6% until February, then there is a huge spike in March (month 9).

This is in line with the monthly average new COVID-19 patients' rates, which is shown in the bar chart as follows:

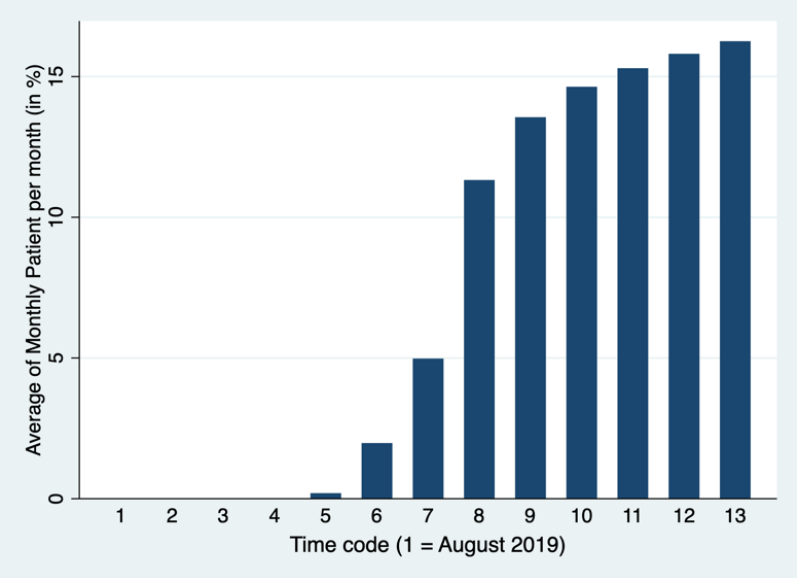

Figure 2: Monthly increase in average COVID-19 patients in percentage

Until November 2019 (month 4), no case was confirmed. Then, the number gradually increased in January in Asia, later spreading across Europe and the rest of the countries. Ideally, more months should be added in to improve the quality of the research, which could be implemented when more data becomes available in a few months or a year. In addition, percentage values are calculated using the natural log of monthly new patient numbers. In order to avoid the mathematic error when there is no patient (as ln(0) cannot be defined), we calculated ln(#of patients + 1) as a proxy.

Finally, a list of countries(currencies) used in the analysis is shown below with their descriptive statistics.

Table1.1: Descriptive statistics of exchange rate (per USD)

# of observations = 221				
Country	**Mean**	**Std.Err.**	**[95% Conf.Interval]**	
Australia (AUD)	1.483605	.0172742	1.449561	1.517649
Canada(CAD)	1.344169	.0093898	1.325664	1.362675
Italy(EUR)	1.116923	.0090146	1.099157	1.134689
Japan(JPY)	107.8461	.3354899	107.1849	108.5073
Brazil(BRL)	4.673508	.1736006	4.331375	5.015641
China(CNY)	7.032846	.0173772	6.998599	7.067093
Finland(EUR)	1.116923	.0090146	1.099157	1.134689
France(EUR)	1.116923	.0090146	1.099157	1.134689
Denmark(DKK)	6.705177	.0441523	6.618161	6.792193
Columbia(COP)	3577.308	62.28356	3454.559	3700.057
The Netherlands(EUR)	1.116923	.0090146	1.099157	1.134689
Norway(NOK)	9.3893	.1449825	9.103568	9.675032
Mexico(MXN)	20.89328	.542271	19.82457	21.96199

South Korea(KRW)	1196.51	5.620176	1185.434	1207.586
Sweden(SEK)	9.539269	.0984707	9.345203	9.733336
United States (USD)	1	0	-	-
United Kingdom(GBP)	.6754067	.0075005	.6606246	.6901888

The rates show the prices of one unit of USD in respective currencies. Thus, when the exchange rate increases, it means that the currency has depreciated against the US dollar. If we calculate these values directly as dependent values, that ignores differences in the exchange values across countries. In order to solve this issue, we first convert these values into the log form. Then, 1st lag differences are calculated to find the exchange fluctuations in percentage.

Results

Unemployment rate fluctuations

We first begin discussing the effect of the change in monthly coronavirus patients on the unemployment rate fluctuations. In the first model 1.1, coronavirus patients at time t is used. If the result from this model is more significant than the model using lagged value, it implies that there is an immediate effect of the number of monthly patients on the unemployment rate. The table below describes the results of the two models; no lag and 1st lagged model (Model 1.2).

Table 2.1: The effect of the change in COVID patients on the unemployment rates

n =204 Independent variables	Model 1.1 R^2=0.213	Model 1.2 R^2=0.217
$\Delta \ln COVID_{i,t}$	0.004 (0.007)	
$\Delta \ln COVID_{i,t-1}$		0.008 (0.007)
October 2019	-0.000 (0.039)	-0.000 (0.038)
November 2019	-0.006 (0.039)	-0.006 (0.039)
December 2019	-0.026 (0.039)	-0.024 (0.039)
January 2020	0.014 (0.041)	0.020 (0.039)
February 2020	-0.022 (0.045)	-0.024 (0.041)
March 2020	0.002 (0.060)	0.003 (0.044)
April 2020	0.181*** (0.042)	0.134* (0.060)
May 2020	0.033 (0.039)	0.018 (0.042)
June 2020	0.027 (0.039)	0.021 (0.039)
July 2020	-0.008 (0.0392)	-0.012 (0.039)
August 2020	-0.504 (0.039)	-0.053 (0.039)
Constant	0.002 (0.027)	0.002 (0.028)

*p<0.1 **p<0.05 ***p<0.001

*SE in the brackets are computed as $\sigma/\sqrt{n}$

According to Model 1.1, a 1% change in the log of COVID patients positively influences the change in the unemployment rate by 0.4 % in September 2019, which the result is not statistically significant. This result is rational because we did not observe any patients until December 2019, so we cannot observe the effect of the COVID patients on any variables before then. The effect is more significant in April 2020, where we find a jump in the number of COVID patients, and this is also the time where most countries enacted their first restrictive measures. In April 2020, we found that the 1% change in the log of COVID patients increases the log of unemployment rates by 18.5% at a 1% significance level. Overall, the effect of independent values on the dependent values is marginal for both lagged and non-lagged models, so we cannot accept our hypothesis that there is a significant effect of COVID patients on the unemployment rates. In neither model, internal validity is fully achieved due to possible omitted biases, such as government reaction to the pandemic, or level of travel restrictions.

In the second step, the effects of restrictive measures are included in the model as dummy variables. The table below shows the results of the fixed effect analysis. Month dummy variables are used in the model but not shown on the table.

Table 2.2: The effect of restrictive measures

n =204 Independent variables	Model 1.3 R^2=0.213	Model 1.4 R^2=0.218
$\Delta \ln COVID_{i,t}$	0.005 (0.007)	
$\Delta \ln COVID_{i,t-1}$		0.009 (0.007)
Lockdown	-0.005 (0.026)	-0.006 (0.026)
Constant	0.002 (0.027)	0.002 (0.028)

*p<0.1 **p<0.05 ***p<0.001

According to Model 1.3, it could be seen that there are only marginal effects of these measures on the exchange rate fluctuations. Interestingly, the effects are negative for both

Model 1.3 and 1.4, suggesting that the unemployment rates do not increase, but perhaps decrease after activating the restrictive measures. This could be related to the fact that these measures are effective in suppressing the virus, hence workers can get back to working or get an alternative job in a relatively short period. It could also be that restrictive measures facilitated internet environments in various settings such as schools or offices and created more employment opportunities in the IT industry.

Yet, these coefficients are statistically insignificant, and therefore we are unable to identify a clear relationship between the unemployment and the measures. To improve the explanatory power of the research, more data points and information about the employment situations are required.

Exchange rate fluctuations

In this section, we discuss the effect of coronavirus on exchange rate fluctuations. The table below shows the simplified version of the fixed-model analysis. Coefficients for each month are summarized in the appendix.

Table 2.3: Exchange fluctuations and weekly new patients

n=204	Model 2.1	Model 2.2
Independent variables	R^2=	R^2=
$\Delta \ln COVID_{i,t}$	0.003 (0.002)	
$\Delta \ln COVID_{i,t-1}$		-0.003* (0.002)
Constant	-0.002 (0.007)	-0.002 (0.007)

*p<0.1 **p<0.05 ***p<0.001

In Model 2.1, we look at the effect of a change in the log of monthly COVID patients on the exchange rate fluctuations (in the log form) at time t. Since the exchange rate is calculated as the price of a dollar in each currency, an increase of the exchange rate implies the depreciation of the currency. The result indicates that when there is a 1% change in the log of COVID patients, the exchange rate positively fluctuates by 0.3%. Given its low explanatory power, we cannot conclude that the result is significant.

According to Model 2.2, we find a similar result with higher statistical significance. It shows that when the log of COVID patients changes by 1 % at time t-1, the exchange rate negatively fluctuates by 0.3% at t at the 10% significance level. In contrast to our hypothesis that the number of COVID patients and the exchange rates are positively correlated (hence depreciation), the result shows that it appreciates after a month. Overall, the result is not sufficient to conclude any clear relationship between the two variables. It is important to realize that all the countries in this dataset are affected by the coronavirus, so the effect on the exchange rates are offset by each other, resulting in the marginal overall effect.

Conclusion and evaluation

In this paper, we investigated the effect of change in the corona patients on two macroeconomic factors using Fixed-Effect models. From the empirical analysis, we found that there is a positive(unfavorable) effect of the change in monthly new patients on unemployment rate fluctuations, but the result is not statistically significant. Time-fixed variables also had some effects especially in April 2020 when the virus started spreading. However, the coefficients of these time dummies are not statistically significant, thus it cannot fully explain the relationship between the two variables. Thus, we failed to reject our null hypothesis that the monthly new COVID patient rates and the unemployment rates do not correlate.

In the second step, we analyzed the effect of different restrictive measures in selected countries. Due to a low number of observations, we were unable to find a significant result. However, if the coefficients of these variables indicate the correct sign (which was negative), we can still argue that the effects of the restrictive measures were favorable to the society because unemployment decreased after the measure. In order to confirm this argument, we must include more data points for different countries.

Lastly, we investigated the effect of the change in log COVID patients on the exchange rate fluctuations. In contrast to our initial hypothesis that the effect would be positive (depreciation), we have found the negative effect at the 10% significance level when we used the lagged model. The possible explanation for the result could be that because exchange rates are relative to each other, positive and negative effects offset each other and resulted in a rather marginal overall effect.

In addition, we should keep in mind that there could be omitted variable bias that is time-variant, such as the number of travelers or change in medical environments. Adding these variables into the analysis will increase the explanatory power of the model, and the internal validity of the research.

Overall, we have found that there are negative impacts of the spread of coronavirus on the macroeconomic factors although the result we found was not statistically significant. Thus, the policymakers and the governments must suppress the virus as soon as possible and recover from the recession. To identify the measure that is both effective in suppressing the virus and have little damage to the economy, more data must be included in the analysis once they are available. Until then, I conclude that the lockdown/restrictive measures seem to satisfy both of the criteria, hence could be implemented by more nations to overcome this pandemic.

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Appendix

Appendix 1.1: The detailed result of the time fixed model 1.3 & 1.4

n =204 Independent variables	Model 1.3 R^2=0.213	Model 1.4 R^2=0.218
$\Delta \ln COVID_{i,t}$	0.005 (0.007)	
$\Delta \ln COVID_{i,t-1}$		0.009 (0.007)
$Lockdown_{i,t}$	-0.005 (0.026)	-0.006 (0.026)
October 2019	0.000 (0.039)	0.000 (0.039)
November 2019	-0.006 (0.039)	-0.006 (0.039)
December 2019	-0.026 (0.039)	-0.025 (0.039)
January 2020	0.014 (0.041)	0.020 (0.039)
February 2020	-0.022 (0.045)	-0.024 (0.041)
March 2020	0.004 (0.062)	0.008 (0.048)
April 2020	0.184*** (0.046)	0.138* (0.062)
May 2020	0.036 (0.044)	0.022 (0.046)
June 2020	0.030 (0.042)	0.023 (0.042)
July 2020	-0.008 (0.040)	-0.011 (0.039)
August 2020	-0.050 (0.040)	-0.052 (0.039)
Constant	0.002 (0.028)	0.002 (0.028)

*p<0.1 **p<0.05 ***p<0.001

Appendix 1.2: The detailed result of the time fixed model 2.1 & 2.2

n =204 Independent variables	Model 2.1 R^2=0.189	Model 2.2 R^2=0.191
$\Delta \ln COVID_{i,t}$	0.003 (0.002)	
$\Delta \ln COVID_{i,t-1}$		-0.003* (0.002)
October 2019	0.011 (0.009)	0.010 (0.009)
November 2019	-0.003 (0.009)	-0.003 (0.009)
December 2019	0.002 (0.009)	0.003 (0.009)
January 2020	-0.008 (0.009)	-0.002 (0.009)
February 2020	0.004 (0.012)	0.017* (0.010)
March 2020	0.018 (0.014)	0.045*** (0.011)
April 2020	0.009 (0.010)	0.034* (0.014)
May 2020	-0.001 (0.010)	0.009 (0.010)
June 2020	-0.019 (0.009)	-0.014 (0.010)
July 2020	0.007 (0.010)	0.010 (0.009)
August 2020	-0.004 (0.009)	-0.001 (0.009)
Constant	-0.002 (0.007)	-0.002 (0.007)

*p<0.1 **p<0.05 ***p<0.001