The Impact of Covid-19 and Its Policy Response on Korea's Export

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Abstract

The lockdown policies, which are composed of various measures like workplace closing, cancel public events, stay-at-home requirements, are adopted to block the transmission of COVID-19. It may succeed in blocking the infections, but it has negative impacts on the global economy in terms of production and consumption. In this research, the author tries to focus on the impacts of COVID-19 and its policy responses on Korea's exports by using COVID-19 case and death data, policy response data from OxCGRT, immobility data from Google. The importing countries' COVID-19 and the policy responses have negative impacts on Korea's exports even though some of the indicators are not statistically significant. Also the country groups such as OECD, EU, ASEAN, and OPEC have shown the mitigation of negative impacts of COVID-19 and its policy responses and immobility. Korea's COVID-19 situation, its policy responses and immobility in the workplace have positive impacts on Korea's exports. The author also tries to check the baseline's results by doing the estimation with product division, adding time-lag variables, and dividing the region by capital and non-capital area and confirms that the direction of coefficients except medical industries. This study contributes to suggest rough ideas about the impact of lockdown measures on Korea's exports.

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Introduction

The COVID-19 which firstly appeared in December 2019, in China, spreads to many countries. Since there is fast transmission by the patients without any symptoms, WHO has reached to declare pandemic in March 2020 (WHO, 2020) and each country closes the borders and enforces lockdown to block the transmission. People give up their daily life and endure the many difficulties. The lockdown measures, which makes closing the workplaces and schools, banning the public or private gatherings, have a positive effect to reduce the patients and deaths of COVID-19, but there are huge socio-economic costs to pay. Unemployment and reduction in income and decrease of consumption are the representative costs that each government needs to pay. Since the situation of COVID-19 is prolonged, it makes the governments to weigh disinfection and economy.

Meanwhile, Korea is one of the countries that has relatively little impacts from pandemic. Although there was a huge transmission example of COVID-19 in February 2020, afterward, Korea is known as the country that could control the situations without the complete lockdown by utilizing ICTs and open and transparent policy (Lee et al, 2020).

However, the Korean economy is not free from the impact of COVID-19. People try to react to their consumption constraints concentrating on the goal, which is managing the epidemics risk, therefore the production is decreased in various industries such as travel and service industries. According to the Aum et al (2021), Korea has shown a similar level of unemployment problem compared to the countries which apply the complete lockdown, even though there is no complete lockdown to block the transmission. Also in the production and exports, the number of the new exporting companies and the companies which have an increase in the amount of export are decreased (Hong, 2021).

Fortunately, Korea's export has recovered after the huge decrease in April, and the IMF(2021) predicts the prospects of the Korean economy positively. Although there is recovery in the economy, in the other perspectives, the COVID-19 brings the new problem to the global trade environment as a trigger. Export controls to specific products and the shut-down of production facilities make global corporations, which are relying on the global value chains, face uncertainty.

Although the lockdown has caused the changes in the trade order, the studies about the impact of the lockdown itself on Korea's export are in shortages. In the previous studies from Hayakawa and Mukunoki (2021), Korea is included into the analysis as an example of the many countries in the world. We need to focus on the Korea's situation because even there is no complete lockdown, the regulations to limit the people's daily life which are named as 'social-distancing measures' take an effect. Also Korea is not free from the impact of trade-partner countries' lockdown policies since Korea is deeply involved in global value chains (GVC). Therefore it is worth to think about the problem that how Korea's export is vulnerable to the new kinds of the risk and shocks coming from the epidemics, and how the globalization and its relationship have offset the risks.

The possibility of applying the strict policies of lockdown to deal with COVID-19 situation is relatively low comparing to the before, still there is a possibility that we need to tighten the reins again following the COVID-19 situation, and it will be the great background to establish the principles regarding the risk of new epidemics emergence. Therefore, the author tries to look into the impacts of lockdown and social-distancing measures of COVID-19 on Korea's bilateral exports by using the data of March to December in 2020 and 2019.

At first, the author tries to confirm the impact of COVID-19 on export briefly by using

the number of new cases and deaths of COVID-19. Then the author tries to analyze the impact of lockdown policies and social-distancing measures by using the policy response data from OxCGRT. Also the author utilizes the immobility data downloaded from the Google mobility trend data to double-check whether its estimation results also show similar results comparing to the results using the policy response data from OxCGRT. In the estimation results, the author suggests two versions with the country groups and without country groups. The author tries to confirm whether the country groups' coefficients mitigate or deteriorate the importer's impacts and whether the coefficients of importing countries are constant whether there are the country group variables or not. Then, the author tries to do robustness check with products division, time-lag variables, and region division.

In the next chapter, the author tries to review the literature regarding the studies about the COVID-19 and other epidemics on economy, and the impact of COVID-19 on the Korean economy. In chapter 3, the author introduces what kind of the data the author used to express the lockdown measures' influences and suggests the estimation results. In chapter 4, the author attempts robustness check by doing estimation with product division, adding time-lag variables, and dividing the regions. In the last chapter, the author presents the conclusion and limitations.

Literature Review

In this chapter, the author tries to review the literature on how the impacts of epidemics on the economy have been studied, how COVID-19 is different comparing to other epidemics like SARS and MERS, and how the impacts of COVID-19 on Korean economy have been studied. By doing so, the author tries to draw the implications and to suggest the purpose of the study.

Infectious disease on economy

The impacts of epidemics on economy have been studied more complicatedly than before since the globalization connects the countries. The research paradigm has been changed from focusing on quarantine costs and temporary productivity reduction to the people's consumption activity changes. In the beginning, it has been studied with the concept of 'cost of illness' regarding the cost of treating patients directly and indirect costs like productivity reduction because of patients increase (Byfold et al, 2000). After the SARS, the impact of new epidemics on the economy has been studied in more various fields (Keogh-Brown & Smith, 2008). Its range is extended to the economic recession and the change of individual's consumption due to the epidemics (Lee and McKibbin, 2004). People tend to reflect the risk to their consumption constraints when there is a new epidemic occurrence like SARS (Brahmbhatt and Dutta, 2008). Much research has been conducted concentrating on the industry of services and travel because the governments control the border strictly and regulate the individual's travel to prevent transmission. Then the research shows that there is the decline of travel and leisure in the after of SARS (Brahmbhatt and Dutta, 2008). The decrease of visitors in Korea in 2015 is also correlated to MERS (Joo, 2019).

The process of COVID-19 effects on the economy is similar to the process of existing

epidemics. Since the government closes the borders and imposes the restrictions, the economy has been affected through the various channels like unemployment, decrease demands in travel and service industries, and production decreases (Maliszewska et al, 2020). The deaths of COVID-19 may affect to the consumer's utility function (Hall et al, 2020). Then the COVID-19 lead to the reduction in aggregate demand in importing countries (Hayakawa and Mukunoki, 2020). The decrease in outputs and varieties therefore caused the inflation in most product categories (Xavier and Connell, 2020).

Meanwhile there are different points of COVID-19's disinfection policies compared to other epidemics. The differences come from that there is fast transmission with the patients without any symptoms and the virus mutates rapidly (Miyawaki and Tsugawa, 2021). According to Abiad et al (2020), COVID-19 exceeds the total number of SARS patients quickly. In the past, SARS and MERS were spread to specific regions like China and Hongkong, and Middle East and South Korea, and its impact was concentrated on those regions (Tanaka, 2021). However, with the fast transmissions, the number of deaths and patients of COVID-19 is explosively increased, therefore WHO declared the pandemic in March 2020 (WHO, 2020).

Then the government utilizes the enormous resources and executes strong disinfection policies and border closures to protect the people's health. The new measures are applied which are named as lockdown. Most of the governments apply the additional disinfection policies, for example, preventing social gatherings, school closing, and workplace closures which permeate to people's daily life more sharply. Also the new living habits such as wearing masks, checking the temperature, and washing hands are emphasized to prevent the transmission even if the people are not infected. (Miyawaki and Tsugawa, 2021) It is effective to block the transmission of COVID-19 in some degrees. According to Ullah (2020), the total number of

confirmed cases are decreased by lockdown policies.

While the COVID-19 situation is prolonged and the lockdown measures accompany the costs, various factors need to be considered to make lockdown policies work effectively. Moser and Yared (2021) point out the governments of commitment is important to the business because lack of government's commitment may turn investments into sunk costs. Kaplan et al (2020) emphasize that the government should consider which subjects bear the economic costs burden from COVID-19 when the disinfection policies are designed. Also the individuals' capacity to stand opportunity costs needs to be consider to make partial lockdowns are effective (Bonardi et al, 2020). Lastly the active testing policies are required to reduce the risk of huge transmission after the reopen (Wung Lik, 2020). Therefore the problem of blocking transmission is being more complicated.

Solving the problems of disinfection starts from the clarifying the impacts of each lockdown policies on the society. Especially in the economy, many research have done focusing on the impact of the workplace closures and stay-home-requirements on production and consumption activities. Staying at home requirements induce the large declines in restaurants and stores (Alexander et al, 2020; Yang et al, 2020; Wellenius et al, 2020). Also the workplace closures and the staying at home requirement worsen the unemployment problem. It is because it prevents the production activities especially in manufacturing sectors and decreases the demand in services sectors which hire many workers (Avidu and Nayyar, 2020; Bartik et al, 2020). Unemployment and income decline problem are known to be more serious in vulnerable groups which have lower education and low paid jobs (Hawkins, 2020; Gamio, 2020; Kramer and Kramer, 2020). Then the government tries to support by fund and release the regulations to decrease the polarization.

In the international trade, however, the impact of lockdown policies is not always be negative. Stay at home requirements and workplace closures affect negatively to the international trade in some degrees, but the demands for essential and medical products and production activities through global value chains make recovery of international trade (Hayakawa and Mukuonoki, 2020; Hayakawa and Mukunoki, 2020; Hayakawa, Mukunoki, 2021). While the production capacity and the dependence on trade are different by country or the regions, the further studies are needed focusing on the specific country's trade.

COVID-19 on Korea economy

Korea is considered as the one of the (Asian) country which records relatively little damages of COVID-19 patients and deaths. It is because the government has previous experiences dealing with the epidemics such as SARS and MERS, and the active responses in the initial stages (Miyawaki and Tsugawa, 2021). Korean government tries to react to the COVID-19 with three big principles, transparency, democracy, and openness (Lee et al, 2020), and to utilize the sufficient and effective ICTs to trace the patients and COVID-19 situations.

Even though Korea has a relatively better COVID-19 situation, the Korean economy is not free from the influence of COVID-19. People adapt themselves to new-normal life by decreasing the consumption at first. Kim et al *(*2020) confirms that people adjust their consumption activities not to face the risk of virus. Production is decreased in diverse fields like travel and leisure service industry, and the unemployment rate is increased. Since the government imposes the regulations to multi-use facilities, the income of the people is decreasing, and unemployment problem gets serious. Aum et al (2021) claim that the Korea has serious unemployment problem as much as the United States and United Kingdom even

there was no complete lockdown. It would be presumed that even though there is no 'complete' lockdown in Korea, social-distancing measures which limit individuals' life have been applied, and at the same time, Korea is not free from the spillover of implementing lockdown measures in other countries.

Korea's export and production area are suffered from the COVID-19. The first quarter of 2020, which is the early days of COVID-19, although it did not have much impact because of the inventory of existing supplies, it has occurred the difficulties in the customs clearance and logistics (KIET, 2020). Especially in the automobile and automobile components industry, the amount of exports, the number of export company are largely decreased because of the shut-down of factories in the overseas (Hong, 2021). Also the researchers figure out that there is a negative impact on production and exports from the shocks of COVID-19 in the Korean manufacturing industrial clusters (Choi, 2021).

Meantime what Korea has pay attention to when studying the impact of COVID-19 on export is how the world trade order will be changed and how to deal with these changes. Before the pandemic, specialization under the global value chains (GVC) increases the efficiency and it makes economic growth in the end (Goo, 2020). However, while the pandemic occurs, export controls are imposed to some of medical supplies and agricultural products to manage the COVID-19 situations (Gwak, 2020). Also the lockdown measures occur the multi-national corporations' production problem by the delay of transaction between the borders, conflicts in transport, and constraint of people's movement (Goo, 2020; Choi, 2021). These aspects show the vulnerable points of GVC that what would be happened if the domestic production relied on GVC, with specific countries. In the case of Korea, it would be a trigger that shows the necessity of de-sinicization and diversification of export/import partner countries (Joe, 2020;

Kang and Do, 2020).

It is important to study the impacts of lockdown policies on trade prepare the post-COVID-19 generation and the risk of the new epidemics occurrences. Since social distancing measures' impacts are more complicatedly appeared in international trade depending on the region and the industry, and Korea is the country, which is deeply participated in the global value chains, the studies focusing on Korea's trade, especially the exports, are needed to check whether these measures are important variables changing the export trends. In the next chapter, the author suggests the data and estimation results.

Model and Data

Model

In this chapter, the author tries to estimate the impact of COVID-19 on Korea's bilateral export. The author tries to estimate the impact of lockdown policies using PPML-estimation. Hayakawa and Mukunoki (2020) studied how international trade is affected by lockdown policies during the first half of the year 2020 by using PPML-estimation. PPML-estimation is regarded as the great way that has supplemented the problem of zero-trade flow and effective model to analyze the impact of trade policy changes (Yotov et al, 2016). After doing PPML-estimation, the author carries out the RESET Test, Ramsey Regression Equation Specification test to prove the model's validity.

$$Export_{iym} = exp\ \{COVID_i + COVID_{Korea} + \delta_y + \delta_i\} \cdot \epsilon_{iym}$$

Data

To do the research, the author collects the export data and the data which describes the responses coming from the COVID-19. Then the author makes a balanced panel for 99 countries that contains COVID-19 cases, deaths data, policy data, and immobility data. The author sets the estimation period from March to December in 2019 and 2020 to avoid the influences of vaccinations. The dependent variable, which is Korea's bilateral monthly export by country, is collected from Korea customs service and the unit of the export value is 1,000 US dollars.

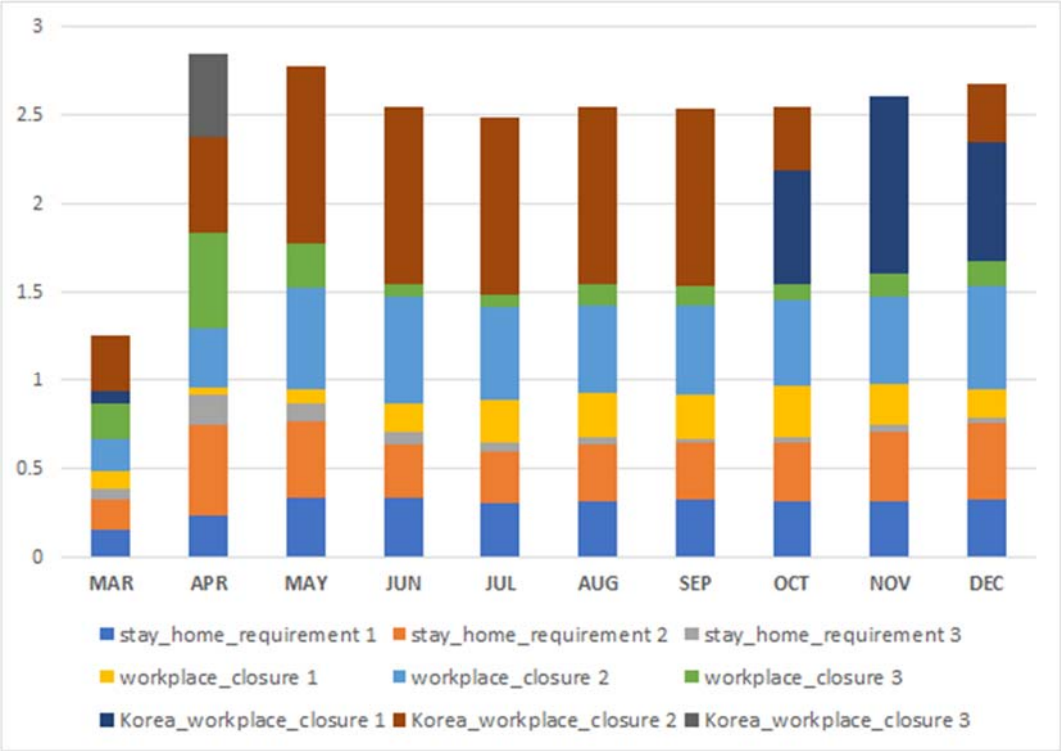
Basically, the author uses COVID-19 cases and deaths data to simply check whether there's impact of COVID-19 on the export. The number of new cases and deaths of COVID-19 is collected from Johns Hopkins University. Then the author calculates fatality rates of

COVID-19 by dividing new deaths by new cases per month. As Padhan and Prabheesh (2021) have figured out there are negative economic effects because of COVID-19's fatalities, the author includes to this indicator whether there is a negative impact on Korea's export. For the year 2019, the cases, deaths, and fatality rate are set to zero.

Second data is about the government's policies which are adopted because of COVID-19. OxCGRT(Oxford Covid-19 Government Response Tracker) collects government responses to COVID-19 in several categories like school closing, transportation closing by day. Among them the author focuses on two indicators, workplaces closures and stay-home requirements.

Even Hayakawa and Mukunoki (2020) represents stay-home-requirements for importing countries to describe the shock of consumption demand side and workplace closure for exporting countries to describe the supply side, the author tries to apply both measures to each equation. Meanwhile Korea is expected to respond to COVID-19 on demand of intermediate goods considerably because Korea has a high proportion of intermediate goods in trade. Therefore the author tries to apply both stay-home requirements and workplace closures indicators to the estimation in order to estimate the impact of policy response of COVID-19 on Korea's bilateral exports. First, the author uses the stay-home-requirement indicator to express importing countries' COVID-19 severity as Hayakawa and Mukunoki (2021) did, to estimate the consumption demand changes. Also, the author utilizes the workplace closures indicators to importer countries' COVID-19 severity to estimate the correlation between the lockdown policy measures from COVID-19 and demand changes of materials in production. By doing so, the author tries to confirm how the impact of lockdown measures, which regulates the individuals' freedom and mobility, affects Korea's export in various perspectives.

There are four degrees to describe the density of the regulations and the policy to regulate the people's activities are getting stronger from no regulation to recommendation and to minimal exceptions with requirement not to leave the house and close workplaces. Since OxCGRT collects daily responses of COVID-19, the author calculates the proportion of each degree per month by adding up the days of responses per month for each degree and dividing it by the days of each month.



[Figure 1: Average of each policy responses]

In Korea, the degree 3 of workplace closures, which is the strongest measure, is applied in April 2020, and April is also the only month which applies the degree 3. Korea applies degree 2 from May to September, and the degree 1 and degree 2 are applied in a mixture after that. In the case of importers, the average of workplace closures degree 1 to 3 are implemented in a mixed manner. The ratio of degree 3 is highest in April just like Korea's case, then it has

decreased over time. Although importer's degree 3 of workplace closures is the highest policy response in April, in the case of stay-home requirements, degree 2 is the degree which records the highest degree in April. The degree 2 of importer's workplace closure is increased in May and June and the degree 1 is relatively increased as the COVID-19 situation is entered into a stable period. In the case of importer's stay-home requirements, the degree 1 and degree 2 are intersected to similar levels, and its distribution is mixed.

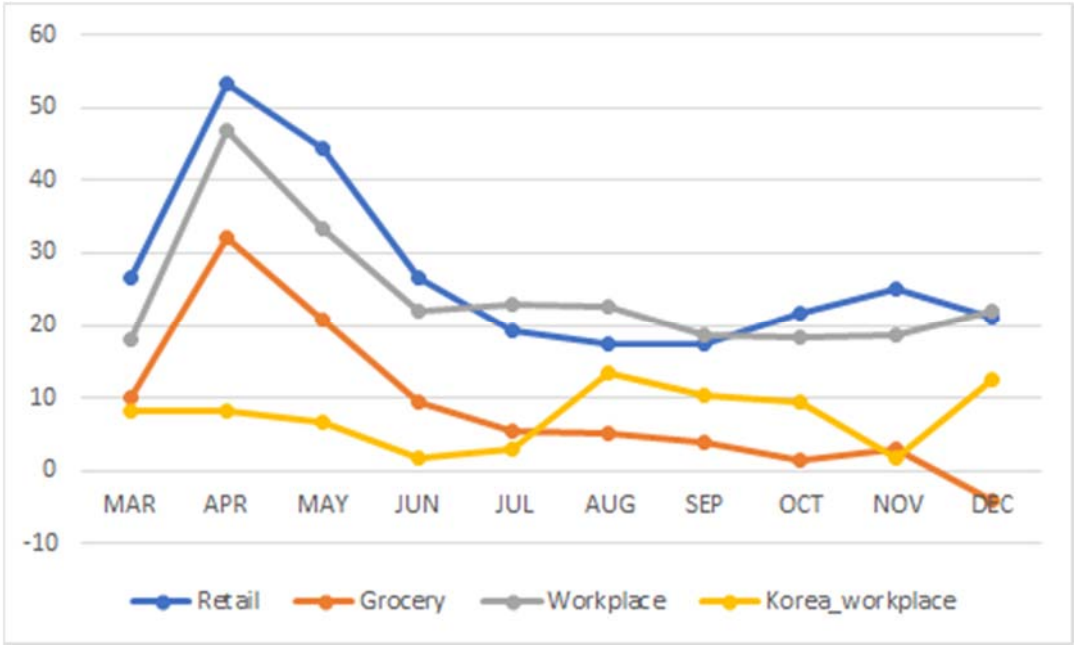
Since the policy responses tend to appear in a mixture per each month, the author adds all the degrees in the estimation. Since there is a collinearity problem, zero degree of workplace closures and stay-home requirements in importing countries and degree zero and three of workplace closure responses in Korea are excluded. There is a possibility of an endogeneity problem in terms of using all policy response degrees in an equation. However, since the various degrees are mixed even in a month and the decision making in policy response degree happens independently according to the COVID-19 situation, which is given randomly, the author decided not to worry too much about the endogeneity problem.

The last data expresses people's immobility compared to before the pandemic. By using this data, the author tries to double check whether the policy responses on COVID-19 have similar. To express immobility, the author collects mobility trend data from google. In google, it suggests the data report which shows how the number of visitors has changed comparing to the baseline period (before the pandemic, from January 3rd, 2020, to February 6th, 2020).

Meanwhile, regarding the Google's mobility data, Hayakawa and Mukunoki(2021) pointed out that since the lockdown date shares and immobility index have different distributions about people's activities though both indexes represent the COVID-19 situations. Also Google, which supplies the mobility data, have advised that the mobility data would be

used as a reference analyzing the impact of COVID-19 since the data is not free from the effects of holidays and weekends (Google, 2021). However, the author thinks that the mobility data is a kind of effective index that shows how the lockdown and social-distancing policies make mobility changes based on people's mobile-phone data. Therefore, the author would like to check the lockdown policy's impact on Korea's exports again using mobility data.

Referring to Hayakawa and Mukunoki(2021)'s way, the author expresses immobility by multiplying minus one to the mobility data from Google. Also the author handles immobility data of year 2019 as missing value since it would be meant that the extent of immobility is similar to the baseline period if the data is treated as zero for 2019 data. Then the author tries to figure out the increase in immobility has correlation to Korea's export and to confirm whether its results are similar to the results using the policy response data from OxCGRT.



[Figure 2: Average immobility trends]

The author chooses the importer countries' retails, grocery, and workplace's immobility to analyze the impact of lockdown policies on Korea's export. The retail and recreation category includes places like restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters. The grocery and pharmacy category includes places like grocery markets, food warehouses, farmers markets, drug stores and pharmacies. The workplaces category reflects the mobility trends for places of work. In the case of Korea, the immobility category is fixed to workplace immobility because the author focuses on Korea's production activities from the perspective of an exporter country.

In the case of importing countries, the immobility of all categories dramatically increased in April. After the immobility hit the peak in April and declined, it shows the different tendency. The retail's immobility is decreased until September and it rises again from October. However, the immobility of grocery is continually decreasing, and it records a negative number in December, which means that people's mobility increases. Lastly workplace's immobility in importing countries repeats the increase and decrease after June, but its range of fluctuation has decreased compared to before. Meantime Korea's immobility in the workplace repeats increase and decrease but its variance is relatively small comparing to importer's immobility fluctuations. Also, Korea's immobility in the workplace tends to gently decrease except in August.

Estimation Results

Baseline estimation results

1) COVID-19 report

$$Export_{iym} = exp\ \{COVID_i + COVID_{Korea} + \delta_y + \delta_i\} \cdot \epsilon_{iym}$$

	COVID Case (log (case + 1))		COVID Death (log(death+1))		Fatality (new death/new case)	
	baseline	with group	baseline	with group	baseline	with group
Importer	-0.0020008	-0.0151502**	-0.0005648	-0.0161623**	-1.180113 **	-2.885265**
Standard error	0.0039988	0.0053638	0.0041691	0.0063056	0.3423002	1.3338777
[p-value]	[0.617]	[0.005]	[0.892]	[0.010]	[0.001]	[0.031]
Korea	0.1063627***	0.1084919***	0.0967721***	0.0944457***	-2.055584***	-2.097338***
Standard error	0.009252	0.0092174	0.0106727	0.0103852	0.5730703	0.5641014
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Importer * OECD		0.0110487**		0.0173645**		1.601952
Standard error		0.0038285		0.006045		1.371433
[p-value]		[0.004]		[0.004]		[0.243]
Importer * EU		0.0055217*		0.0096412**		0.6446283
Standard error		0.0028356		0.0044179		0.5574971
[p-value]		[0.052]		[0.029]		[0.248]
Importer * ASEAN		0.0002399		0.0067358		2.071982
Standard error		0.0043266		0.0088501		1.501138
[p-value]		[0.956]		[0.447]		[0.168]
Importer * OPEC		-0.0115082*		-0.0273394**		-3.704334
Standard error		0.0060018		0.0104901		2.598024
[p-value]		[0.055]		[0.009]		[0.154]
_cons	10.16852***	10.24721***	10.62738***	10.69262***	11.09218***	11.12002***
Standard error	0.0814367	0.0816274	0.0567067	0.0580849	0.0384866	0.0422721
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
RESET TEST	0.1345	0.3742	0.0510	0.6271	0.1285	0.1953
Wald Statistics	224945.24	233157.35	223910.89	230963.34	205078.19	205892.15
log pseudolikelihood	-9963738.138	-9654458.827	-10458038.02	-10135567.1	-11272892.16	-11158096.9
Pseudo R2	0.9885	0.9889	0.9879	0.9883	0.9870	0.9871

Number of obs.	1,980	1,980	1,978	1,978	1,980	1,980

[Table 1: Baseline results _ COVID-19 cases, deaths, fatality rate]

*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels. The baseline results will be suggested by two versions, without country group and with the country groups. The author tries to distinguish the baseline results by two versions because the author wants to check whether there is mitigation or deterioration following the country groups. Please refer to the [appendix 1] to check which countries are included in the panel and which countries are parts of OECD, EU, ASEAN, and OPEC.*

International business, trade and travel make people connect and meet closer and frequently even if they live overseas. Unfortunately, the characteristics that people have comforts make the COVID-19 transmission faster (Shrestha et al, 2020). According to Farzanegan et al (2021), the more the country is globalized, the higher COVID-19 fatality rate is recorded. Therefore, the governments enforce the restrictions to mobility and lockdown measures to prevent the infections. It would be successful to block COVID-19's transmission at some point, but it gives limitations to international business and trade.

From the baseline results, the author could confirm that the impact of importers' COVID-19 cases, deaths, and fatality rates on Korea's exports are negative, and its result is in line with Shrestha et al (2020). Since the number of COVID-19 cases, deaths, and fatality rates have increased, Korea's exports have decreased. It would be because increase in COVID-19 cases, deaths, and fatality rates would be the reasons the governments apply the lockdown measures which lead to the restrictions of production and consumption activities in the end.

In the results included country groups, the size of negative impacts of importer's COVID-19 cases, deaths, and fatality rates are bigger than the estimation results without the country groups and it is statistically significant in the level of 95%. Based on the estimation results that coefficients of group variables, OECD, ASEAN, and EU, are positive, the author figures out that the country group mitigates the importer's impacts of COVID-19 on exports. Since the countries in the groups would mean that they are more actively participating in the global economy and politics, the positive coefficients of each country group could be

interpreted that countries' efforts to decrease the effects of border closure are reflected (Sigler et al, 2021). But in the case of the OPEC group variable, it seems to worsen the negative impacts on exports. It would be the results reflecting the socio-economic factors like age, education, and access to health care services. By the way, some of the estimation results need attention since they are not statistically significant.

The cases and deaths of COVID-19 affect Korea's export positively, except fatality rates. Korea also appears similarly with small differences in the results which include country groups. All the three indicators are statistically significant in the level of 99%. Korea is one of the active countries to have efforts to maintain close relationships with various economic cooperation/organization and FTAs, and deeply involved in global value chains (GVC). In terms of that, Korea's positive coefficients of COVID-19 cases and deaths can be interpreted as the results of globalization. Korea's government tries to minimize the border closures from the beginning of the COVID-19 pandemic, and it is in line with the claims of Sigler et al (2021). Also, there is another possibility to the reason why the coefficients of Korea's COVID-19 cases and deaths are positive to exports that the demands of Korea's major exports are increased because of COVID-19 special. Electronic devices and medical products, which demand has increased due to COVID-19 and telecommuting, are the major exports. Regarding this point, the author tries to check whether there is a product effect by doing additional estimation in terms of product division in the next chapter.

2) Policy responses

	Importer: workplace closure Korea: workplace closure		Importer: stay-home-requirement Korea: workplace closure	
	without country group	With country group	without country group	with country group
Importer Degree 1	-0.0463458	-0.000267	-0.0278202	-0.232281
Standard error	0.0401632	0.0698174	0.0340106	0.44084
[p-value]	[0.249]	[0.997]	[0.413]	[0.598]
Importer Degree 2	-0.0147925	-0.0864275	-0.0294027	-0.1959447**
Standard error	0.0356239	0.0554294	0.041299	0.0692789
[p-value]	[0.678]	[0.119]	[0.476]	[0.005]
Importer Degree 3	-0.0648111	-0.1834101*	-0.167656**	-0.3173796**
Standard error	0.0577907	0.1081841	0.0830425	0.1120192
[p-value]	[0.262]	[0.090]	[0.043]	[0.005]
Korea Degree 1	0.4327853***	0.4241014***	0.4385176***	0.4532761***
Standard error	0.0920049	0.1034408	0.0810142	0.0873587
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]
Korea Degree 2	0.218813**	0.2138381**	0.2233986**	0.2472374**
Standard error	0.1008539	0.1086197	0.0896885	0.0936253
[p-value]	[0.030]	[0.049]	[0.013]	[0.008]
OECD * degree 1		-0.0607831		0.022975
Standard error		0.0740945		0.0587423
[p-value]		[0.412]		[0.696]
OECD * degree 2		0.1371341**		0.1650679**
Standard error		0.0567454		0.0783006
[p-value]		[0.016]		[0.035]
OECD * degree 3		0.0888898		0.2162123
Standard error		0.1117973		0.173635
[p-value]		[0.427]		[0.213]
EU * degree 1		0.0416829		0.0180023
Standard error		0.0762543		0.0622306
[p-value]		[0.585]		[0.772]
EU * degree 2		0.0012969		0.0769894
Standard error		0.0427679		0.0611284
[p-value]		[0.976]		[0.208]
EU * degree 3		0.1631331**		-0.089429
Standard error		0.0832643		0.2138139

[p-value]		[0.050]		[0.676]
ASEAN * degree 1		-0.0334788		-0.12207
Standard error		0.0720833		0.0672476
[p-value]		[0.642]		[0.069]
ASEAN * degree 2		0.030607		0.2320954**
Standard error		0.0637346		0.0858456
[p-value]		[0.631]		[0.007]
ASEAN * degree 3		0.1935494		0.336875**
Standard error		0.1269952		0.1299547
[p-value]		[0.127]		[0.010]
OPEC * degree 1		-0.1669207*		-0.327446**
Standard error		0.0902347		0.1149296
[p-value]		[0.064]		[0.004]
OPEC * degree 2		-0.1553445		-0.1799146
Standard error		0.0978121		0.1496013
[p-value]		[0.112]		[0.229]
OPEC * degree 3		0.1484554		0.3322539**
Standard error		0.2683697		0.1579217
[p-value]		[0.580]		[0.035]
_Cons	10.76569***	10.78395***	10.75759	10.79943***
Standard error	0.1070753	0.1145034	0.098435	0.0994094
[p-value]	[0.000]	[0.000]	[0.000]	[0.000]
RESET test	0.0551	0.0663	0.0721	0.7537
Wald statistics	222720.35	238106.67	225661.35	237184.25
log pseudolikelihood	-10412691.47	-10065146.13	-10396834.27	-9946529.302
Pseudo- R2	0.9880	0.9884	0.9880	0.9885
Number of obs	1,980	1,980	1,980	1,980

[Table 2: Baseline estimations of policy response from OxCGRT]

*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels. The baseline results will be suggested by two versions, without country group and with the country groups. The author tries to distinguish the baseline results by two versions because the author wants to check whether there is mitigation or deterioration following the country groups. Please refer to the [appendix 1] to check which countries are included in the panel and which countries are parts of OECD, EU, ASEAN, and OPEC.*

When the author applies a workplace closure response (without country group) as an importer's policy response, the negative effect of degree 2 is smaller than degree 1 while in the

estimation included country group shows the scale of negative is bigger as the degree of policy response is stronger. In the case of using stay-home requirements as an importer's indicator, as the degree of stay-home requirements' intensity gets stronger, the negative impacts on Korea's exports gets bigger. The effect of degree 1 and degree 2 is similar in terms of the scale, but at degree 3, which allows only the minimal exceptions, its negative impact is much bigger. In the estimation with the country group, the coefficients of importers per each degree are much bigger than the estimation without the country groups. But, unlike the case without the country groups, the smallest negative value of the coefficient of degree 2 was shown when the country group was added. According to Hawkins (2020), the workplace is a place where there is a significant infection of COVID-19. The government adopts the regulations in workplaces but there is a limitation remoting the working environments by industries (Shrestha et al, 2020). It may lead to the setback of the production activities especially in the manufacturing sectors therefore the decrease in Korea's exports would be stronger as the degree of workplace closure gets stronger.

In the meantime, the results which utilizes the stay-home requirement as importer's COVID-19 policy response would be followed by the various factors much more than the estimation using workplace closure responses. It is because the stay-home requirements meant not only working in the house but also impossible to go out to consume. The consumers tend to react the constraints from social distancing measures (Avidu and Nayyar, 2020) and prepare for the uncertain risks from the COVID-19, therefore the demand for Korea's exports would be decreased. As the stay-home-requirement includes the importing countries' responses both as consumers and as producers, the author thought that the coefficients of stay-home requirements tend to be bigger than the coefficients of the case using the workplace closures.

On the other hand, Korea's policy response, which is workplace closure, both the coefficients are statistically significant, degree 1 for 99% level and degree 2 for 95% level. Both positively affect Korea's exports, but the size of degree 1 is bigger than degree 2. Korea's workplace closure degree affects Korea's exports at a similar level comparing to the case which uses stay-home requirements to importer's COVID-19 situation. The author could confirm that degree 1 has a bigger positive effect on Korea's exports comparing to degree 2, as well.

Although Korea also has lower remoteness in manufacturing sectors, as the industries which records lower remoteness have larger mitigation effect of lockdown restrictions than home-based work (Avidu and Nayyar, 2020) and Korea does not apply complete or restrictive lockdown measures relatively to other countries (Bendavid et al, 2021), the impact of workplace closures in Korea on Korea's exports seems to be relatively small. Also as Kaushik and Guleria (2020) pointed out, the companies' financial support for teleworking, such as purchase of electronic gadgets and devices, may lead to the increase of demand for Korea's products. Following the reasons, the author suggests the coefficient of Korea's workplace closures would be positive.

3) Immobility

	Retail		Grocery		workplace	
	without group	with group	without group	with group	without group	with group
Importer	-0.0057459***	-0.0116163***	-0.0074345***	-0.0073553***	-0.0093996***	-0.0137147***
Standard error [p-value]	0.0008608 [0.000]	0.0016245 [0.000]	0.0012821 [0.000]	0.0020437 [0.000]	0.0011977 [0.000]	0.00241 [0.000]
OECD		0.0029407		-0.006545**		0.0013748
Standard error [p-value]		0.0022128 [0.184]		0.0030708 [0.033]		0.0028917 [0.634]
EU		0.00929***		0.0104455***		0.0097845***
Standard error [p-value]		0.0018242 [0.000]		0.0029508 [0.000]		0.0024506 [0.000]
ASEAN		0.0040374		0.0001509		0.0059869
Standard error [p-value]		0.0025375 [0.112]		0.0035344 [0.966]		0.003851 [0.120]
OPEC		0.0110407***		0.0054911*		0.0108566**
Standard error [p-value]		0.0023017 [0.000]		0.0029722 [0.065]		0.0035518 [0.002]
KOREA	0.0080973**	0.0082681**	0.0082336**	0.0085766**	0.0101828***	0.0102366***
Standard error [p-value]	0.002958 [0.006]	0.0029233 [0.005]	0.0029536 [0.005]	0.0030589 [0.005]	0.0029971 [0.001]	0.0030054 [0.001]
_Cons	11.02125***	11.16864***	10.93403***	10.93067***	11.11094***	11.22518***
Standard error [p-value]	0.0544631 [0.000]	0.0616048 [0.000]	0.0513477 [0.000]	0.0541402 [0.000]	0.0628853 [0.000]	0.0836877 [0.000]
RESET Test	0.0025	0.0286	0.2948	0.7056	0.0304	0.1416
Wald statistics	90796.65	95101.71	84602.00	88851.30	94921.18	99341.11
log pseudolikelihood	-6163569.252	-5634610.718	-6261595.845	-6146683.06	-5938776.276	-5757420.125
Pseudo R2	0.9857	0.9869	0.9855	0.9857	0.9862	0.9866
Number of obs	990	990	990	990	990	990

[Table 3: Baseline estimations using immobility]

*Notes: The immobility data is from Google, which is based on the user's agreement of data collection. The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels. The baseline results will be suggested by two versions, without country group and with the country groups. Please refer to the [appendix 1] to check which countries are included in the panel and which countries are parts of OECD, EU, ASEAN, and OPEC.*

Korea's exports are decreased when the immobility is increased in grocery stores of

importing countries and immobility in the workplace is also negative to Korea's exports. The impact of immobility in the importer's workplace is bigger than the impact of immobility in the grocery stores in the importing countries. The coefficients of Korea's immobility in the workplace are positive in both estimation results. Also, the country group dummies have mitigated the negative impact of importers as the other baseline results did.

The scales of coefficients of immobility are smaller than the baseline estimation results using policy response from OxCGRT. It may be because the increase in immobility does not necessarily mean the decrease in consumption and trade. Since the delivery services and the online shopping industry are remarkably growing, people could satisfy their needs even though they don't go to the actual physical places and the way they enjoy and consume the goods and services are changed (Alexander et al, 2020). In addition, the immobility may have different appearances depending on how many social-distancing measures are implemented at the same time (Wellenius et al, 2020). Therefore, we have to be careful interpreting the estimation results using immobility even though it shows a similar direction of coefficients comparing to the case using policy responses from OxCGRT.

Robustness Check

The author has confirmed that there is a negative impact of importing countries' COVID-19 severity on Korea's exports while there is a positive impact of Korea's COVID-19 responses on Korea's exports. Also the author could identify that each country group may mitigate or deteriorate the impacts of the policy responses for COVID-19 on Korea's exports. In this chapter, the author attempts to take a look at the baseline results in the various perspectives by doing the additional estimations in terms of the products, time-lag, and regions. Then the author would suggest the implications and limitations of the research.

Products division

In the analysis about why Korea's coefficients are positive to Korea's exports, the author has suggested the idea that there is the possibility that Korea's exports have met the COVID-19 special. To prove this idea, the author did the estimation by replacing the total exports with medical products or top-18 products in the dependent variables. The amount of exports of medical products or top-18 products would be calculated on the basis of HS-2 code for top-18 products and HS-4 code for medical products. The indicators expressing the COVID-19 severity are 1) COVID-19 cases, deaths, and fatality rates, and 2) policy responses from OxCGRT.

1) COVID-19 reports

	COVID Case			COVID Death			COVID Fatality rate		
	Baseline	Top 18	Medical	Baseline	Top 18	Medical	Baseline	Top 18	Medical
Importer	-0.0151502**	-0.0150567**	0.0897386***	-0.0161623**	-0.0162488**	0.0802904***	-2.885265**	-3.070944**	0.6395659
Standard error [p-value]	0.0053638 [0.005]	0.0057295 [0.009]	0.0111328 [0.000]	0.0063056 [0.010]	0.0066698 [0.015]	0.0115442 [0.000]	1.3338777 [0.031]	1.426811 [0.031]	1.970719 [0.746]
OECD	0.0110487**	0.0114223**	-0.0298478***	0.0173645**	0.0180946**	-0.0456579***	1.601952	1.753354	-4.671458**
Standard error [p-value]	0.0038285 [0.004]	0.0040168 [0.004]	0.0074426 [0.000]	0.006045 [0.004]	0.0063214 [0.004]	0.0108236 [0.000]	1.371433 [0.243]	1.457217 [0.229]	2.07419 [0.024]
EU	0.0055217*	0.005772**1	0.0618215***	0.0096412**	0.0102034**	0.0842455***	0.6446283	0.6953821	2.572941**
Standard error [p-value]	0.0028356 [0.052]	0.0029299 [0.049]	0.0089093 [0.000]	0.0044179 [0.029]	0.0045711 [0.026]	0.0133334 [0.000]	0.5574971 [0.248]	0.5781901 [0.229]	1.193875 [0.031]
ASEAN	0.0002399	0.0010536	0.0009651	0.0067358	0.0086487	0.016097	2.071982	2.69703*	-5.604
Standard error [p-value]	0.0043266 [0.956]	0.0047079 [0.823]	0.010579 [0.927]	0.0088501 [0.447]	0.0099888 [0.387]	0.0179711 [0.370]	1.501138 [0.168]	1.599379 [0.092]	2.960902 [0.058]
OPEC	-0.0115082*	-0.0110993**	0.0547211***	-0.0273394**	-0.0250013**	0.0982242***	-3.704334	-2.838395	-6.357805
Standard error [p-value]	0.0060018 [0.055]	0.0056245 [0.048]	0.0101425 [0.000]	0.0104901 [0.009]	0.0096542 [0.010]	0.0200075 [0.000]	2.598024 [0.154]	2.390187 [0.235]	3.909978 [0.104]
KOREA	0.1084919***	0.1100799***	0.0587077**	0.0944457***	0.0948962***	0.0967925***	-2.097338***	-2.220814***	1.086225
Standard error [p-value]	0.0092174 [0.000]	0.009478 [0.000]	0.0250781 [0.019]	0.0103852 [0.000]	0.0106799 [0.000]	0.0252051 [0.000]	0.5641014 [0.000]	0.5874111 [0.000]	1.108923 [0.327]
_cons	10.24721***	10.08628***	6.370156***	10.69262***	10.54397***	6.873332***	11.12002***	10.98039***	7.801041***

Standard error [p-value]	0.0816274 [0.000]	0.0858289 [0.000]	0.2525834 [0.000]	0.0580849 [0.000]	0.0617712 [0.000]	0.1624143 [0.000]	0.0422721 [0.000]	0.0453282 [0.000]	0.1083389 [0.000]
RESET test	0.3742	0.3888	0.1423	0.6271	0.1733	0.2083	0.1953	0.2270	0.0008
Wald statistics	233157.35	209659.24	26918.11	230963.34	209091.25	25432.85	205892.15	185595.70	18954.23
log pseudolikelihood	-9654458.827	-9552362.221	-625921.0867	-10135567.1	-10031257.28	-632853.6785	-11158096.9	-10926234.78	-755241.7862
Pseudo R2	0.9889	0.9879	0.9250	0.9883	0.9872	0.9241	0.9871	0.9861	0.9095
Number of obs	1,980	1,980	1,980	1,978	1,978	1,978	1,980	1,980	1,980

[Table 4: Robustness check of COVID-19 report by product division]

*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels.*

Please refer to the [appendix 1] to check which countries are included in the panel and which countries are parts of OECD, EU, ASEAN, and OPEC. The HS-4 Codes for medical products and HS-2 Codes for Top-18 products are included in the [appendix 2]

At first, when the author utilizes COVID-19 cases to express COVID-19 severity, in the case of Top-18 products as dependent variables, the importer's coefficient is similar to baseline results. The coefficient of Korea also has similar positive impacts on Korea's exports. However, in the medical products, importing countries' coefficients are positive and the coefficient of Korea is also reported as positive, but its scale remained about half. It is because domestic demand for medical products in Korea increased while the Korean government predicts the sudden rise of COVID-19 cases then expands the testing policies and imposes export controls on medical products temporarily.

Continually, in the case of COVID-19 deaths as COVID-19 severity and exports of Top-18 products as dependent variables, the author could confirm the similar coefficients of Korea and importers. In the case using the exports of medical products in the dependent variable, as the

importing countries' deaths of COVID-19 increase, exports of Korea's medical products are increased and the increase of deaths in Korea has positive impact on Korea's exports similarly as the baseline results and the results using Top-18 products' exports. In addition, the author could have confirmed that there is the mitigation effect of country groups in both cases.

When the author uses fatality rates as COVID-19 severity and uses the amount of Top-18 products as dependent variable, the coefficients of Korea and importers have more pessimistic impacts to Korea's exports than baseline. It is shown because there is the impact of lockdown measures and the workplace closures. Korea's 18 major exports are mostly electronic materials or devices which are built on the manufacturing sector, which is the industry that is hard to remote the working environments. In the case of medical products as dependent variable, the higher fatality rates of importing countries and Korea lead to the more Korea's exports of medical products.

2) Policy response

	(1)	(2)	(3)	(4)	(5)	(6)
Policy response	Importer: workplace closure Korea: workplace closure			importer: Stay home requirement Korea: workplace closure		
Dependent	Baseline	Top 18	Medical	Baseline	Top 18	Medical
Importer Degree 1	-0.000267	-0.0074391	0.2858693*	-0.232281	-0.0295028	0.3634849**
Standard error [p-value]	0.0698174 [0.997]	0.0747137 [0.921]	0.1464021 [0.051]	0.44084 [0.598]	0.0468983 [0.529]	0.1404423 [0.010]
Importer Degree 2	-0.0864275	-0.0914866	0.6160178***	-0.1959447**	-0.1923238**	0.3285618**
Standard error [p-value]	0.0554294 [0.119]	0.0569408 [0.108]	0.0994849 [0.000]	0.0692789 [0.005]	0.0732529 [0.009]	0.1260847 [0.009]
Importer Degree 3	-0.1834101*	-0.1756646	1.021367***	-0.3173796**	-0.325067**	0.3206309**
Standard error [p-value]	0.1081841 [0.090]	0.1146653 [0.126]	0.1766354 [0.000]	0.1120192 [0.005]	0.1240548 [0.009]	0.133254 [0.016]
OECD * degree 1	-0.0607831	-0.0630136	-0.0297335	0.022975	0.0360637	-0.2651682
Standard error [p-value]	0.0740945 [0.412]	0.0809388 [0.436]	0.1422743 [0.834]	0.0587423 [0.696]	0.0615414 [0.558]	0.163609 [0.105]
OECD * degree 2	0.1371341**	0.1468671**	-0.1820524	0.1650679**	0.1609451**	-0.3286715**
Standard error [p-value]	0.0567454 [0.016]	0.0578259 [0.011]	0.119455 [0.128]	0.0783006 [0.035]	0.0816808 [0.049]	0.1325428 [0.013]
OECD * degree 3	0.0888898	0.0793948	-0.5089532**	0.2162123	0.2572191	0.3426506**
Standard error [p-value]	0.1117973 [0.427]	0.1176868 [0.500]	0.1895218 [0.007]	0.173635 [0.213]	0.1924367 [0.181]	0.1626478 [0.035]
EU * degree 1	0.0416829	0.0493304	0.3263137**	0.0180023	0.0074962	0.2629769
Standard error [p-value]	0.0762543 [0.585]	0.0806892 [0.541]	0.1177956 [0.006]	0.0622306 [0.772]	0.0644608 [0.907]	0.1633255 [0.107]
EU * degree 2	0.0012969	0.0047265	0.4371743***	0.0769894	0.0821356	0.8720263***
Standard error [p-value]	0.0427679 [0.976]	0.0437555 [0.914]	0.1221738 [0.000]	0.0611284 [0.208]	0.0629196 [0.192]	0.1767775 [0.000]
EU * degree 3	0.1631331**	0.153516	0.8022402***	-0.089429	-0.0939536	-1.716007**
Standard error [p-value]	0.0832643 [0.050]	0.0836126 [0.066]	0.24143 [0.001]	0.2138139 [0.676]	0.217897 [0.666]	0.8415518 [0.041]
ASEAN * degree 1	-0.0334788	-0.032725	-0.4029387**	-0.12207*	-0.129988*	-0.2281853
Standard error [p-value]	0.0720833 [0.642]	0.079134 [0.679]	0.184422 [0.029]	0.0672476 [0.069]	0.0719424 [0.071]	0.2022108 [0.259]
ASEAN * degree 2	0.030607	0.0363542	-0.2928109**	0.2320954**	0.2408238**	-0.3018433**
Standard error [p-value]	0.0637346 [0.631]	0.0666334 [0.585]	0.1291925 [0.023]	0.0858456 [0.007]	0.0906693 [0.008]	0.1539534 [0.050]
ASEAN * degree 3	0.1935494	0.2096139	-0.6547216***	0.336875**	0.378383**	-0.5531925**

Standard error [p-value]	0.1269952 [0.127]	0.1345267 [0.119]	0.2048937 [0.001]	0.1299547 [0.010]	0.1476765 [0.010]	0.2305991 [0.016]
OPEC *degree 1	-0.1669207*	-0.2051856**	0.6274341***	-0.327446**	-0.3218137**	0.0847735
Standard error [p-value]	0.0902347 [0.064]	0.0922022 [0.026]	0.1770982 [0.000]	0.1149296 [0.004]	0.1062404 [0.002]	0.2034315 [0.677]
OPEC * degree 2	-0.1553445	-0.1006973	0.7244789***	-0.1799146	-0.1242646	0.2665965
Standard error [p-value]	0.0978121 [0.112]	0.0899231 [0.263]	0.1345208 [0.000]	0.1496013 [0.229]	0.1423709 [0.383]	0.2157736 [0.217]
OPEC * degree 3	0.1484554	0.2616286	0.9818665	0.3322539**	0.3847634**	1.09227***
Standard error [p-value]	0.2683697 [0.580]	0.2548033 [0.305]	0.7139501 [0.169]	0.1579217 [0.035]	0.1646729 [0.019]	0.2018134 [0.000]
Korea degree 1	0.4241014*** *	0.4577226***	0.4726155**	0.4532761***	0.4813567***	0.3220501
Standard error [p-value]	0.1034408 [0.000]	0.1116107 [0.000]	0.2071771 [0.023]	0.0873587 [0.000]	0.0935634 [0.000]	0.2273965 [0.157]
Korea degree 2	0.2138381**	0.2440461**	0.1373547	0.2472374**	0.2757724**	0.1404644
Standard error [p-value]	0.1086197 [0.049]	0.1167498 [0.037]	0.2173546 [0.527]	0.0936253 [0.008]	0.0997579 [0.006]	0.2272868 [0.537]
_Cons	10.78395***	10.60996***	7.040842***	10.79943***	10.62554***	7.350398***
Standard error [p-value]	0.1145034 [0.000]	0.1226588 [0.000]	0.2384469 [0.000]	0.0994094 [0.000]	0.1064619 [0.000]	0.2590199 [0.000]
RESET Test	0.0663	0.0451	0.1209	0.7537	0.6773	0.6662
Wald Statistics	238106.67	213682.71	23207.95	237184.25	209574.46	23060.30
log pseudolikelihood	-10065146.13	-9900214.876	-629968.3744	-9946529.302	-9818186.894	-659596.3634
Pseudo R2	0.9884	0.9874	0.9245	0.9885	0.9875	0.9209
Number of obs	1,980	1,980	1,980	1,980	1,980	1,980

[Table 5: Robustness check of policy response by product divisions]

*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels. Please refer to the [appendix 1] to check which countries are included in the panel and which countries are parts of OECD, EU, ASEAN, and OPEC. The HS-4 Codes for medical products and HS-2 Codes for Top-18 products are included in the [appendix 2]*

When the importer policy responses are workplace closure, in the estimation (2), the direction of the coefficients for Korea and importers coincide with the baseline and the scale is similar. In the estimation (3), which is the case that applies the amount of medical products' export as dependent variable, it shows a different appearance that all the coefficients of importers' degree are positive and as the degree goes up, the increase range gets bigger. While the degree is getting stricter means that the COVID-19 situation gets worse and needs the more

medical products especially in the developed countries (Shrestha et al, 2020), the estimation results would be coincided with the normal perceptions even if it is not accorded with the baseline results. In addition, when the stay-home requirement is used to express the policy response of importing countries, in the estimation (5), the coefficients of all the degrees for importers and Korea are similar to the baseline results. However in the estimation (6), which applies the medical products as the dependent variable, it has differences. All the importer's degrees have positive coefficients and especially the degree 1's coefficient is the largest positive impact on Korea's medical products exports. The scale of importer's degree 2 and 3 is similar. The reason why this situation is happened probably because people tend to buy more medications and supplies to prepare for the situations which adopt stricter restrictions (Wellenius et al, 2020). Korea's coefficients are still positive even though its positive scale is smaller than the baseline results.

The author could confirm the robustness of baseline results by comparing the estimation results of Top-18 products. It would have small differences, but in most cases, it has a similar scale of the coefficients for each indicator comparing the baseline results. This is because Korea's major exports are related to the industry which does not have big changes in demand and supply because of COVID-19 (Koo, 2020). In addition, in the results using the medical products' exports, the author could check the fact that there is an increased demand in Korea's medical products. Even if the COVID-19 situation gets serious, the exports of medical products also increase.

Time-lag

The standards of lockdown measures of COVID-19 are usually adopted based on the COVID-19 situations of the last two-three weeks. In Korea, the government presents the number of confirmed patients per 100,000 people and degree of risk during the last two weeks, and the social-distancing measures are controlled based on those results. Also the export decision making tends to have two-three weeks intervals to reflect in the real charts considering the transportation. According to those reasons, the author tries to check the impacts of last month's lockdown measures on the current month's exports. Then the author makes the variables of one-month time lag to each degree, and especially for time-lag variables in March is handled as zero. Also, the country group variables are not included.

$$Export_{iym} = exp\ \{COVID_i + L.COVID_i + COVID_{Korea} + L.\ COVID_{Korea} + \delta_y + \delta_i\} \cdot \epsilon_{iym}$$

	(1) Baseline	(2) Time-lag	(3) Baseline	(4) Time-lag
	importer: workplace closure Korea: workplace closure		importer: stay-home requirement Korea: workplace closure	
Importer degree 1	-0.0463458	-0.048037	-0.0278202	0.0023956
Standard error [p-value]	0.0401632 [0.249]	0.0455736 [0.292]	0.0340106 [0.413]	0.0387754 [0.951]
Importer degree 2	-0.0147925	-0.0198072	-0.0294027	-0.0038944
Standard error [p-value]	0.0356239 [0.678]	0.0520005 [0.703]	0.041299 [0.476]	0.0393291 [0.921]
Importer degree 3	-0.0648111	-0.0524165	-0.167656**	-0.0303185
Standard error [p-value]	0.0577907 [0.262]	0.0597583 [0.380]	0.0830425 [0.043]	0.0942888 [0.748]
L. Importer degree 1		0.0532852		-0.0577634
Standard error [p-value]		0.0482582 [0.270]		0.0411577 [0.160]
L. Importer degree 2		0.052834		-0.0364877
Standard error [p-value]		0.0571007 [0.355]		0.0435034 [0.402]
L. Importer degree 3		0.0840756		-0.2285585**

Standard error [p-value]		0.0668682 [0.209]		0.1146684 [0.046]
Korea degree 1	0.4327853***	0.5297151***	0.4385176***	0.6229915***
Standard error [p-value]	0.0920049 [0.000]	0.0925515 [0.000]	0.0810142 [0.000]	0.0869659 [0.000]
Korea degree 2	0.218813**	0.4716584***	0.2233986**	0.5741497***
Standard error [p-value]	0.1008539 [0.030]	0.1085643 [0.000]	0.0896885 [0.013]	0.1073713 [0.000]
L. Korea degree 1		-0.012257		0.0729771*
Standard error [p-value]		0.0508708 [0.810]		0.0402221 [0.070]
L. Korea degree 2		-0.1467828**		-0.0676317*
Standard error [p-value]		0.0510931 [0.004]		0.0376068 [0.072]
L. Korea degree 3		-0.7074427***		-0.5652105***
Standard error [p-value]		0.1111517 [0.000]		0.0942912 [0.000]
_cons	10.76569***	10.64929***	10.75759***	10.53187***
Standard error [p-value]	0.1070753 [0.000]	0.1136868 [0.000]	0.098435 [0.000]	0.1035801 [0.000]
RESET Test	0.0551	0.1794	0.0721	0.2797
Wald Statistics	222720.35	254226.99	225661.35	252029.02
log pseudolikelihood	-10412691.47	-9584256.018	-10396834.27	-9495185.798
Pseudo R2	0.9880	0.9890	0.9880	0.9891
Number of obs.	1,980	1,980	1,980	1,980

[Table 6: Robustness check of time lag estimations for policy response]
*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels.*

In the results using workplace closures in the importers' indicator, the coefficients of importers are similar to the baseline results. The time-lag variables show that if there are workplace closures in the last month, the exports of this month increase. The stricter degree is applied in the last month, the bigger increase in Korea's exports in this month. Korea's coefficients of each degree in this month are bigger than the baseline results and the last month's workplace closures in Korea have a negative impact on this month's exports. As the measures are tightened, the negative impacts get bigger.

When the author applied the stay-home requirement in the importer's indicator, they showed a different appearance. The negative impacts of importer's policy responses of the present month decreased, and especially degree 1 has recorded the positive coefficients. However, the 1-month time lag variables of each degree recorded adverse estimations. It is probably because the consumers tend to restrain their consumption to react to the uncertainties coming from the further restrictions. The time-lag variable of degree 3 has the most negative impact on Korea's exports. The coefficients of Korea's workplace closures of the present month have increased. Last month's workplace closures in Korea tend to have a negative impact on Korea's exports. While the coefficient of degree 1 of workplace closures in Korea is positive, the coefficients of degree 2 and 3 are negative. Especially the degree 3 of workplace closures in the last month have strongly negative impacts on the exports.

Capital/Non-capital Division

In the early period of COVID-19, Korea tends to have similar disinfection policies for the whole country. Although there is a mass infection examples in Daegu, February 2020 and the government applies special disinfection policy in that period to Daegu and Gyeong-buk (Ryu, 2020). Since then, similar quarantine policies have been implemented for the whole country due to the sporadic outbreaks of COVID-19. However, there was criticism that the efficiency of COVID-19 reaction decreased since the COVID-19 situation is prolonged and the number of new patients have differences between Seoul-metropolitan area, and non-metropolitan area. Therefore, to better manage Korea's COVID-19 situation better, Korea's social-distancing measures have three big changes in the early May, the end of June, and the early of November. The government implements the social-distancing measures by dividing

the metropolitan area and non-metropolitan area from the end of May (KCDA, 2020). Also each local government could coordinate the social-distancing measures with autonomy under the consultation with the Central Disease Control and Prevention Agency (KCDA, 2020). Therefore, the author would like to further enhance the credibility of the baseline results by checking whether disinfection measures have a similar effect on Korea's exports even when Korea's distancing stage is divided into metropolitan areas and non-metropolitan areas.

The author collects the number of local patients and deaths of COVID-19 from May to December 2020 since some of the regions do not sort the patients from overseas and local outbreaks until April. Then the author calculates the fatality rate by dividing new deaths into new cases. Also the social distancing measures from May to December are collected from the government's regular briefing and news articles. The author only reflects the changes of social-distancing measures in metropolitan areas and non-metropolitan areas even though there are different social distancing measures by smaller provinces and districts with autonomy. As in the case of converting daily data of policy response from OxCGRT into monthly data, the author calculates the proportion of each measure. The COVID-19 data and social-distancing measures in year 2019 set into zero and the google mobility data is excluded because the data is presumed based on Seoul's mobility changes. Also the author includes monthly fixed effects and district fixed effects additionally in this equation.

(1) COVID- response for baseline and specification for capital and non-capital

	Covid case		Covid death		Fatality	
	Baseline	Capital/ non-capital	Baseline	Capital/ non-capital	Baseline	Capital/ non-capital
Importer	-0.0151502**	-0.013555**	-0.0161623**	-0.0146754**	-2.885265**	-1.730806
Standard error [p-value]	0.0053638 [0.005]	0.0057093 [0.018]	0.0063056 [0.010]	0.0065804 [0.026]	1.3338777 [0.031]	1.224457 [0.158]
Importer * OECD	0.0110487**	0.0094386**	0.0173645**	0.0155337**	1.601952	1.103536
Standard error [p-value]	0.0038285 [0.004]	0.0039768 [0.018]	0.006045 [0.004]	0.0061778 [0.012]	1.371433 [0.243]	1.244766 [0.375]
Importer * EU	0.0055217*	0.0066201**	0.0096412**	0.0119101**	0.6446283	0.3254632
Standard error [p-value]	0.0028356 [0.052]	0.0032782 [0.043]	0.0044179 [0.029]	0.0051323 [0.020]	0.5574971 [0.248]	0.5593242 [0.561]
Importer * ASEAN	0.0002399	0.0010773	0.0067358	0.0062885	2.071982	1.572194
Standard error [p-value]	0.0043266 [0.956]	0.0057434 [0.851]	0.0088501 [0.447]	0.0096424 [0.514]	1.501138 [0.168]	1.90594 [0.409]
Importer * OPEC	-0.0115082*	-0.0171311**	-0.0273394**	-0.0342738**	-3.704334	-5.088685**
Standard error [p-value]	0.0060018 [0.055]	0.0064093 [0.008]	0.0104901 [0.009]	0.0109096 [0.002]	2.598024 [0.154]	2.538911 [0.045]
Korea	0.1084919***	0.0954056***	0.0944457***	0.0916244***	-2.097338***	-1.083902***
Standard error [p-value]	0.0092174 [0.000]	0.0107817 [0.000]	0.0103852 [0.000]	0.0117233 [0.000]	0.5641014 [0.000]	0.2478545 [0.000]
_Cons	10.24721***	9.450093***	10.69262***	9.812902***	11.12002***	10.19864***
Standard error [p-value]	0.0816274 [0.000]	0.1127075 [0.000]	0.0580849 [0.000]	0.0782109 [0.000]	0.0422721 [0.000]	0.0554903 [0.000]
Reset test	0.3742	0.0466	0.6271	0.0823	0.1953	0.0433
Wald Statistics	233157.35	169629.87	230963.34	157755.35	205892.15	167876.91
log pseudolikelihood	-9654458.827	-17936751.1	-10135567.1	-18218278.61	-11158096.9	-18836201.79
Pseudo R2	0.9889	0.9750	0.9883	0.9746	0.9871	0.9737
Number of obs.	1,980	3,168	1,978	3,164	1,980	3,168

[Table 7: Robustness check of COVID-19 reports with the specification of region]

*Notes: The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels. The month-fixed effects and the district-fixed effects are added compared to the baseline estimation.*

Compared to the baseline results, the results with separation of capital or non-capital area have shown similar results with small differences. The estimations with capital area

division have relatively smaller coefficients than the baselines' coefficients. It might be because the month-fixed effects and district-fixed effects are supplemented.

(2) Social distancing measures

	(1) Baseline	(2) Capital/Non-capital	(3) Baseline	(4) Capital/Non-capital
Importer's policy response	workplace		stay-home requirement	
importer degree 1	-0.0463458	-0.0479239	-0.0278202	-0.511259
Standard error [p-value]	0.0401632 [0.249]	0.0524471 [0.361]	0.0340106 [0.413]	0.0381121 [0.180]
importer degree 2	-0.0147925	-0.0080622	-0.0294027	-0.0509426
Standard error [p-value]	0.0356239 [0.678]	0.0425964 [0.850]	0.041299 [0.476]	0.0406731 [0.210]
importer degree 3	-0.0648111	-0.0400728	-0.167656**	-0.0760421
Standard error [p-value]	0.0577907 [0.262]	0.0533817 [0.453]	0.0830425 [0.043]	0.1193616 [0.524]
Korea degree 1	0.4327853***		0.4385176***	
Standard error [p-value]	0.0920049 [0.000]		0.0810142 [0.000]	
Korea degree 2	0.218813**		0.2233986**	
Standard error [p-value]	0.1008539 [0.030]		0.0896885 [0.013]	
Korea social distancing level 1.5		0.5000149**		0.5399236**
Standard error [p-value]		0.1830048 [0.006]		0.1936955 [0.005]
Korea social distancing level 2		0.2557162***		0.2568801***
Standard error [p-value]		0.0526644 [0.000]		0.0532887 [0.000]
Korea social distancing level 2.5		0.4153754***		0.4287421***
Standard error [p-value]		0.0687887 [0.000]		0.0686135 [0.000]
_cons	10.76569***	9.921919***	10.75759***	9.943384***
Standard error [p-value]	0.1070753 [0.000]	0.068675 [0.000]	0.098435 [0.000]	0.0670451 [0.000]
Reset test	0.0551	0.1042	0.0721	0.1243
Wald Statistics	222720.35	158951.58	225661.35	156230.16

log pseudolikelihood	-10412691.47	-18349372.66	-10396834.27	-18332817.83
Pseudo R2	0.9880	0.9744	0.9880	0.9744
Number of obs.	1,980	3,168	1,980	3,168

[Table8: Robustness check of social-distancing measures with the region specification]

*Notes: Korea's social distancing level 1 and Korea's workplace closure degree 3 from OxCGRT are excluded because of collinearity. The ***, **, * denote significance at the 0.1%, 5%, and 10% at levels.*

It is hard to compare the estimation results with the baseline estimation in the same line because only the standards of Korea's social distancing measure are changed. However, even considering that point, there are meaningful points to take a look. In the estimation results (2) and (4), even though the author uses another standard of social-distancing measures in Korea, the importer's coefficients have the same directions, which are negative. However the scale of the coefficients is quite different and the author finds the variation of importer's coefficients are bigger in the estimation using stay-home requirement. Meanwhile, the coefficients of Korea in both estimation (2) and (4) are positive and have similar scales.

Conclusion

While globalization and the characteristics of COVID-19 make fast transmissions of COVID-19, each government adopts policies to obstruct the infections. The most representative policy response, which is lockdown policies, are composed of various measures like workplace closing, cancel public events, stay-at-home requirements. It may succeed in blocking the transmission, but it has negative impacts on the global economy. In this research, the author tries to focus on the impacts of COVID-19 and its policy responses on Korea's exports by using COVID-19 case and death data, policy response data from OxCGRT, immobility data from Google.

The importing countries' COVID-19 and the policy responses have negative impacts on Korea's exports even though some of the indicators are not statistically significant. When the author uses the policy responses from OxCGRT, the importing countries' policy responses have negative impacts on Korea's exports, and especially the degree 3 has the greatest negative effects. In the estimation results using immobility, the importing countries' immobility in grocery stores and workplace is negative to Korea's exports while the scales of coefficients are relatively smaller than the results using policy responses from OxCGRT. Also the country groups such as OECD, EU, ASEAN, and OPEC have shown the mitigation of negative impacts of COVID-19 and its policy responses and immobility. Meanwhile, Korea's COVID-19 situation, its policy responses and immobility in the workplace have positive impacts on Korea's exports. In the robustness check, the author tries to check the baseline's results by doing the estimation with product division, adding time-lag variables, and dividing the region by capital and non-capital area.

This study contributes to suggest rough ideas about the impact of lockdown measures on Korea's exports. However there are some limitations in this research. First, some of the countries like China are not included in the panel due to the absence of the data even though the country actively trades with Korea. Also the detailed research is required to prove what kind of the factors, especially socio-economic factors, drive each country group's mitigation or deterioration of negative impacts of whole importers. Lastly, while the local governments try to do autonomous nonpharmaceutical measures based on the region's COVID-19 situation, further studies which apply the smaller district division are required.

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Appendix

Appendix 1. Country panels

[TOTAL COUNTRY]

ARE / ARG / AUS / AUT / BEL / BGD / BGR / BHR / BIH / BLR / BOL / BRA / CAN / CHE / CHL / CIV / CMR / COR / CRI / CZE / DEU / DNK / DOM / ECU / EGY / ESP / FIN / FRA / GBR / GHA / GRC / GTM / HKG / HND / HRV / HUN / IDN / IND / IRL / IRQ / ISR / ITA / JAM / JOR / JPN / KAZ / KEN / KGZ / KHM / KWT / LAO / LBN / LKA / LTU / LVA / MAR / MDA / MEX / MMR / MOZ / MUS / MYS / NGA / NIC / NLD / NOR / NPL / NZL / OMN / PAK/ PAN / PER / PHL / POL / PRT / PRY / QAT / ROU / RUS / SAU / SEN / SGP / SLV / SVK / SVN / SWE / THA / TJK / TTO / TUR / TWN / TZA / UGA / UKR / URY / USA / VEN / VNM / ZAF

[OECD]

AUS / AUT / BEL / CAN / CHL / COL / CRI/ CZE /DEU/ DNK / ESP / FIN / FRA / GBR / GRC / HUN / IRL / ISR / ITA / JPN / LTU / LVA / MEX / NLD / NOR / NZL / POL / PRT / SVK / SVN / SWE / TUR / USA

[EU]

AUT / BEL / BGR / CZE / DEU / DNK / ESP / FIN / FRA / GRC / HRV / HUN / IRL / ITA / LTU / LVA / NLD / POL / PRT / ROU / SVK /SVN / SWE

[ASEAN]

IDN / KHM / LAO /MMR / MYS / PHL / SGP / THA / VNM

[OPEC]

ARE / IRQ / KWT / NGA / SAU / VEN

Appendix 2. HS Code for product division

	Top-18 products	Medical products
	HS-2	HS-4
1	27	3006
2	28	3822
3	29	4014
4	30	7017
5	33	8713
6	38	9018
7	39	9019
8	40	9020
9	71	9021
10	72	9022
11	73	9402
12	74	
13	76	
14	84	
15	85	
16	87	
17	89	
18	90	
total	18	11