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Does Vaccination Mitigate the Negative Impacts of Coronavirus on Trade?

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Keywords: COVID-19; trade; vaccination
JEL Classification: F15; F53

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1. Introduction

The coronavirus (COVID-19) pandemic has negatively affected trade on a global scale. To prevent the spread of the COVID-19 virus, most countries implemented various kinds of nonpharmaceutical interventions, especially those to restrict people's movement. The stay-at-home orders decreased consumption opportunities, shrinking the imports of goods. Similarly, work-from-home impositions decreased production in factories, decreasing the export of goods. Thus, the severity of COVID-19 damages led to a decrease in both exports and imports. According to the press release by the World Trade Organization, the global merchandise trade in 2020 decreased by 5.3%, proving that the COVID-19 pandemic has contributed significantly to the decreasing global trade.

Against this backdrop, vaccines are expected to play a key role in mitigating the negative effects of COVID-19 on trade. International trade has experienced many external

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shocks, including various natural disasters and financial crises. These shocks are mostly temporary in nature. For example, although serious natural disasters may destroy factories, the economy gradually recovers by rebuilding newer factories. In the case of the ongoing COVID-19 pandemic that caused epidemics and outbreaks, the economy cannot fully recover until this virus is contained. To this end, the development of antiviral drugs and vaccines is indispensable. As of September 2021, various drugs and vaccines are available, although their effects are not necessarily clear. In particular, since the end of 2020, many countries have started vaccination drives, which are expected to contribute to economic recovery.

Here, we examined how vaccinations change the effect of COVID-19 on trade by using bilateral trade data from 31 countries between the period of January 2019 and June 2021. By including trade in the prepandemic period (i.e., 2019) in our study sample, we were better able to identify the effects of COVID-19 on trade. Furthermore, our inclusion of the former half of 2021 enabled us to examine the effect of vaccinations. The severity of COVID-19 damages was measured by the number of newly confirmed cases and the death toll. We introduced these COVID-19 variables in exporting and importing countries, with coefficients indicating the effect of COVID-19 on trade. By further introducing the interaction term of this COVID-19 measure with the number of vaccination doses, we investigated how this effect on trade changes according to the increase in vaccination. To control for unobservable factors, we introduced various fixed effects. Finally, we estimated these models by the Poisson pseudo maximum likelihood (PPML) method.

Our main findings are summarized as follows: First, on average, the increase in confirmed cases and the death toll decreased both exports and imports significantly. This result is attributed to the restrictive lockdown orders by the various governments (e.g., stay-at-home and work-from-home impositions) for COVID-19 prevention. Second, such negative effects were mitigated as the number of vaccination doses increased, indicating that governments do not introduce such restrictive orders if a large number of people are vaccinated. In particular, the mitigating effect of vaccines is more significant in exports than in imports. Third, as is consistent with the conjecture above, the effect of COVID-19 severity on the lockdown restrictions decreased with an increase in vaccination doses. This effect of vaccination on lockdown orders is our source of mitigating their effect on the impact of COVID-19 severity on international trade.

Our study is related to two strands of literature on the COVID-19 pandemic. One is the literature on vaccination for COVID-19, which is rapidly growing. Several studies have analyzed the optimal vaccination policy in terms of allocation (Babus et al., 2020; Luyten et al., 2020; Agarwal et al., 2021; Vellodi and Weiss, 2021; Forslid and Herzing, 2021), subsidy (Bosi et al., 2020; Goodkin-Gold et al., 2020), speed (Gros and Gros, 2021), distribution sites (Chevalier et al., 2021), and willingness to pay (Cerda et al., 2021; Dong et al., 2020; García and Cerda, 2020; Sarasty et al., 2020; Wong et al., 2020). For example, Gollier (2021) showed that vaccinating low-risk people in vaccine-rich countries before high-risk people in vaccine-poor countries worsens the global welfare consequences of the pandemic. Similarly, Więcek et al. (2021) examined the nexus among supply speed, efficacy, amount per dose, the interval between the first and second doses, and mortality. Some studies investigated vaccine hesitancy to seek the policy measure to increase its demand (Alsan and Eichmeyer, 2021; Gans, 2021; Thunström et al., 2020; Duquette, 2020; Neumann-Böhme et al., 2020; Bughin et al., 2021; Dabla-Norris et al., 2021; Lazarus et al., 2021).

The other is the literature that analyzes the effect of COVID-19 on international trade. There are several empirical studies on goods trade (e.g., Evenett et al., 2021a; Friedt and Zhang, 2020; Hayakawa and Mukunoki, 2021a, 2021b, 2021c; Kejzar and Velic, 2020; Meier and Pinto, 2020). These studies found that the severity of COVID-19 damages in both exporting and importing countries leads to a decrease in the goods trade. Additionally, some studies showed the propagation of such negative effects throughout supply chains. In particular, some studies demonstrated the role of various tools/strategies in mitigating the negative effects of COVID-19 damages on international trade. For example, Ando and Hayakawa (2021) found that the negative effects on supply chains are mitigated when import sources are diversified. Moreover, Hayakawa et al. (2021) showed that the negative effect of COVID-19 on importing countries decreases with developing E-commerce. Here, we shed light on the role of vaccinations as a tool for mitigation.[1]

The rest of this paper is organized as follows: The next section overviews the time-series changes of COVID-19 cases, vaccination doses, and international trade, followed by our empirical framework in Section 3. Our estimation results and conclusions are present in Sections 4 and 5, respectively.

2. Overview: Confirmed Cases, Vaccines, and Trade

This section gives an overview of the severity of COVID-19 damages and the progress of vaccinations in addition to global trade. The number of cases rose explosively since the World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020. At the same time, the virus has continued to evolve, and several variants have emerged. The expert group convened by WHO has recommended using letters of the Greek alphabet for specific variants[2]. The Beta variant was first documented in South Africa in May 2020, followed by the Alpha variant in the United Kingdom in September that year. Subsequently,

[1] Some studies focus on the trade of medical products. For example, Hayakawa and Imai (2021) found that while an increase in COVID-19 burden leads to decreases in exports of medical products, such a decrease is smaller when exporting to countries with closer political, economic, or geographical ties.

[2] https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/ (Accessed on August 22, 2021)

the Delta and Gamma variants were documented in India in October and Brazil in November 2020, respectively. In particular, according to the Centers for Disease Control and Prevention in the United States, the Delta variant causes more infections and spreads faster[3]. As of September 2021, these variants are designated as variants of concern. Furthermore, several other variants, which are designated as variants of interest, have been identified.

Figure 1 shows the aggregated monthly number of new confirmed COVID-19 cases by region. The data on this number is obtained from the COVID-19 Data Repository maintained by the Center for Systems Science and Engineering at Johns Hopkins University.[4] After the WHO's declaration in March 2020, the number of confirmed cases had experienced an explosive rise. Until the third quarter of 2020, South Asia and Latin America & Caribbean were the main regions with the highest number of cases. After the Alpha variant was documented in the United Kingdom, the number of cases increased sharply in Europe & Central Asia and North America. The global number hit its first peak in January 2021 and decreased in February. Indeed, since February 2021, the number of cases gradually decreased in Europe & Central Asia and North America. However, the global number hit a second peak, which was higher than the first, in April 2021 because of the explosive rise in South Asia. In June 2021, Latin America & Caribbean became the region with the highest number. Another noteworthy point is that at least until June 2021, the number of cases has been relatively small in East Asia & Pacific and Sub-Saharan Africa.

== Figure 1 ==

Scientists have developed potential vaccines for COVID-19. According to the WHO website[5], at least 13 different vaccines have been globally administered, several types of which include "inactivated or weakened virus vaccines," "protein-based vaccines," "viral vector vaccines," and "RNA and DNA vaccines." Evenett et al. (2021b) showed the high concentration and self-reliance in COVID-19 vaccine production among a group of 13 countries[6], which they refer to as the "Vaccine Club." Many countries have made deals with vaccine manufacturers or pharmaceutical companies for vaccination doses. Furthermore, dozens of countries have obtained vaccines through COVAX, a consortium backed by the WHO to guarantee fair and equitable access to every country in the world. According to the

[3] https://www.cdc.gov/coronavirus/2019-ncov/variants/delta-variant.html (Accessed on 22 August 2021)
[4] https://github.com/CSSEGISandData/COVID-19. Also see Dong et al. (2020).
[5] https://www.who.int/news-room/q-a-detail/coronavirus-disease-(covid-19)-vaccines (Accessed on 22 August 2021)
[6] They include Argentina, Australia, Brazil, Canada, China, European Union, India, Japan, Korea, Russian Federation, Switzerland, United Kingdom, and the U.S.

WHO website[7], "(b)ased on what we know so far, vaccines are proving effective against existing variants, especially at preventing severe disease, hospitalization and death."

Figure 2 depicts the cumulative number of COVID-19 vaccine doses administered at the beginning of each month. The first mass vaccination program started in early December 2020 and the number has risen explosively during the study period. As of February 2021, vaccinations are concentrated in the three regions including East Asia & Pacific, Europe & Central Asia, and North America. After which other regions, especially South Asia, have gradually increased the number of vaccinations, with the largest number of doses credited to East Asia & Pacific, attributed mainly to the active vaccinations in China. Nevertheless, because of the global supply shortage, vaccination doses have been biased in rich countries. Indeed, Evenett et al. (2021b) showed that the Vaccine Club accounted for 60% of the total confirmed advance purchasing agreements with pharmaceutical companies for vaccination doses.

== Figure 2 ==

Last, we take an overview of global trade by employing monthly trade data drawn from the *Global Trade Atlas* by IHS Markit[8]. We collected the monthly bilateral trade data for 31 reporting countries from January 2019 to June 2021.[9] For each of them, we were able to obtain exports and imports. However, to avoid possible time lag issues on monthly import data, particularly for long-distance trade via sea freight/sea cargo, we used export statistics, that is, reporting countries' export data. We aggregated these exports by months and normalized monthly global exports in 2020 and 2021 by dividing them by those in the corresponding month of 2019. This evolution of global exports is depicted in Figure 3. Exports began to decrease from March 2020 and dropped sharply afterward, hitting rock bottom in May 2020, which was more than a 20% decrease as compared to the corresponding month in 2019. However, since June 2020, world exports have experienced a rapid recovery, with those in September 2020 going beyond their counterparts in September 2019. Since then, global exports have increased gradually with June 2021 exports accounting for more than a 20% increase than those in June 2019.

== Figure 3 ==

[7] https://www.who.int/news-room/feature-stories/detail/vaccine-efficacy-effectiveness-and-protection (Accessed on 22 August 2021)

[8] See https://connect.ihsmarkit.com/gta/home.

[9] The reporting countries and their trade partners are listed in Appendix A.

3. Empirical Framework

This section presents our empirical framework to examine how vaccinations change the impacts of COVID-19 on trade. As discussed in Section 1, COVID-19 has negative effects on international trade partly due to the imposed lockdown. In major importing countries, the pandemic decreased consumption opportunity through stay-at-home orders, which further worsens business performance and thus lowers revenues and income. Such decreases in consumption opportunity and income result in the shrinking of the demand size and imports of goods. Similarly, work-from-home orders in exporting countries decrease factory production (Dingel and Neiman, 2020). Furthermore, the infection control measures in factories, such as social distancing, may lower productivity (Dutcher, 2012; Etheridge et al., 2020), which in turn results in reducing production sizes and thus exports of goods. In sum, the severity of COVID-19 damages leads to a decrease in both exports and imports of goods.

Vaccination may mitigate these negative effects. The restrictiveness of lockdown orders is chosen based on various elements, including the number of confirmed cases, that of fatalities, or their growth rates. The increase in confirmed cases induced governments to introduce more restrictive lockdown orders. However, as discussed in the previous section, vaccines are believed to be effective in the prevention of severe disease, hospitalization, and death. Thus, even if the number of confirmed cases increases, restrictive orders may not be imposed if the number of vaccinated persons is considerably large. Indeed, some countries relaxed the restrictiveness of lockdown orders depending on the share of vaccinated persons (e.g., 70% of the total population in the United States.). In sum, the increase in vaccine doses is expected to reduce the negative effects of COVID-19 on international trade by lowering the restrictiveness of lockdown orders.

Our study, which extended from January 2019 to June 2021, analyzed the monthly for 31 reporting countries along with 220 partner countries, and adhered to the following empirical model:

$$\begin{aligned} Trade_{ijym} = \exp\{ & \alpha_1 \ln(1 + COVID_{iym}) + \alpha_2 \ln(1 + Vaccine_{iym}) \\ & + \alpha_3 \ln(1 + COVID_{iym}) \times \ln(1 + Vaccine_{iym}) + \beta_1 \ln(1 + COVID_{jym}) \\ & + \beta_2 \ln(1 + Vaccine_{jym}) + \beta_3 \ln(1 + COVID_{jym}) \times \ln(1 + Vaccine_{jym}) \\ & + \delta_{ijy} + \delta_{ijm} + \delta_{ym}\} \cdot \epsilon_{ijym}, \end{aligned} \quad (1)$$

where $Trade_{ijym}$ indicates export values from country i to country j in month m of year y. $COVID_{iym}$ shows the number of newly confirmed cases in country i in month m of year y. Similarly, $Vaccine_{iym}$ indicates the cumulative number of vaccine doses as of the beginning of each month. We control for three kinds of fixed effects (δ_{ijy}, δ_{ijm}, and δ_{ym}), which will be explained below. ϵ_{ijym} is a disturbance term. We estimated this equation using the PPML method.

In the baseline estimation, we used the number of new confirmed cases as a measure of COVID-19 damages. Its coefficient in exporting and importing countries indicates the effects of those damages on exports and imports, respectively. Later, we computed the number of COVID-19 related deaths. Alternatively, as a measure of vaccination progress, we used the cumulative number of COVID-19 vaccination doses that were administered. In the case of vaccinations, the cumulative number would be important in the decision of lockdown orders rather than the number of new doses within a month because the rise of the share of vaccinated persons out of the total population is expected to decrease the number of persons in serious conditions. Although we did not divide the number of vaccination doses by total population, our measure was equivalent to its share in the total population because of the introduction of country pair fixed effects as explained below.[10] With controlling for the level of this number, we introduced its interaction term with the number of confirmed cases. The coefficient for this interaction term indicates how the effects of confirmed cases on trade change according to the number of vaccination doses.[11]

Our fixed effects control for various elements, with country pair–year fixed effects (δ_{ijy}) capturing the effects of standard gravity variables such as geographical distance in addition to those of trade agreements, importer's annual demand sizes, and exporter's annual factor prices (e.g., wages). Additionally, this type of fixed effect works to control for the total population. Country pair–month fixed effects (δ_{ijm}) control for the seasonality of trade between the two countries. The country pair component in these fixed effects addressed an endogeneity concern on the variable of vaccination doses. When a country is a manufacturer of COVID-19 vaccines, more doses of vaccines may be supplied to its partner country if the latter is a closer trade partner. Such inherent trade link is controlled by the country pair component in the fixed effects above. Moreover, the number of confirmed cases may contain an error depending on the country's ability to detect the COVID-19 cases. If the magnitude of such an error is related to the country's economic development level, it is controlled by the country–year component. Last, δ_{ym} represents the year–month fixed effects. This type of fixed effect may capture the major type of variants in the world.

The data on the variables in equation (1) are obtained from the same sources as in the previous section. There are two data issues, one being that in the *Global Trade Atlas*, which is our data source for trade, China reported only aggregated trade in January and February in 2020. In Figure 3, therefore, we used the trade values that are equally divided between two months as a trade figure for each month. In our estimation analysis, we simply dropped observations for January and February in 2020 that are reported by China. The second issue

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[10] We did not directly use the data on total population in order to avoid the decrease of the number of study countries due to the data unavailability.

[11] One issue is the possible correlation between *COVID* and *Vaccine*. Namely, the increase of vaccine doses may reduce the severity of COVID-19, especially the number of deaths. However, we did not have observable variables that affect the severity of COVID-19 other than *Vaccine*. If we used only *Vaccine* and drop *COVID*, our estimates suffered from omitted variable bias. Thus, we introduced both variables.

is that for each reporter, we have both export and import statistics. As mentioned in the previous section, the use of export statistics enables us to minimize possible time lag between the production month and the trading month reported in trade statistics. This issue is relevant since our analysis is conducted at a monthly level, not an annual level. Alternatively, in general, import statistics are more accurate than export statistics because of the motivation of collecting import duties. Thus, although we used the export statistics in the baseline analysis, the import statistics were used as a robustness check.

4. Empirical Results

This section presents our estimation results of equation (1). Standard errors are clustered by country pairs. We begin with the estimation of the equation without vaccine variables to see the average effect of COVID-19. Column (I) in Table 1 reports the result using export statistics. Both the coefficients for the importer's and exporter's COVID-19 variables are estimated to be significantly negative. As is consistent with Hayakawa and Mukunoki (2021c), the absolute magnitude is slightly larger in the exporter's COVID-19 variables than in the importer's. A rise of 1% in the confirmed cases decreased exports by 0.010% and imports by 0.009%. This result does not drastically vary when using import statistics, as shown in column (III). Furthermore, in columns (II) and (IV), we used the number of confirmed deaths as a measure of COVID-19 damages. When using import statistics, the coefficients for the importer's COVID-19 variables were negative but insignificant. Nevertheless, in all estimations, those for exporter's were significantly negative.

=== Table 1 ===

Next, we estimate equation (1) and illustrate the results in Table 2. Noninteracted COVID-19 variables in both importer and exporter have negatively significant coefficients. Similarly, the coefficients for noninteracted vaccine variables in both importer and exporter are negative and significant. The negative result in vaccinations can be overlooked as this indicates the effect of vaccinations when no cases/deaths are observed.[12] Our main variables, the interaction terms, have significantly positive coefficients for both exporter and importer. Thus, although the severity of COVID-19 damages decreased both exports and imports, such negative effects were mitigated as the number of vaccination doses increased, as is

[12] The results when excluding interaction terms are available in Table B1 in Appendix B. In this case, the coefficients for vaccine doses are insignificant or significantly positive. In addition, we also estimated our model by industry (HS Section classification), though we did not find remarkable differences across industries. The results are shown in Table B2 in Appendix B.

consistent with our expectation. For example, a 1% increase in vaccinated persons in exporting countries decreased the negative effect of new cases on their exports by 0.001%.

=== Table 2 ===

We conducted one robustness check and specifically excluded China from our study countries because it is an exceptional country in terms of the number of vaccinated persons, the availability of vaccination doses, or the type of vaccines. The results are reported in Table 3. Most columns show the insignificant coefficients for the interaction term in importers, whereas the interaction term in exporters again has significantly positive coefficients. Thus, the mitigating effect of vaccines is more significant in exports than in imports. The insignificant effect on imports may indicate the change of lifestyle. As a consequence of the pandemic, society has gradually become familiar with online shopping as one of the major styles of purchase. According to *eMarketer*, retail E-commerce sales in the world grew by 25.7% from 2019 to 2020. As a result, the relaxation of lockdown orders based on the vaccinations may not significantly change people's consumption amount and thus, imports.

=== Table 3 ===

Last, we examined the effect of vaccination doses on the restrictiveness of lockdown orders. As discussed in the previous section, our conjecture on the effect of vaccines on trade was that the progress of vaccinations lowers the restrictiveness of lockdown orders. To check this effect, we estimated the following equation:

$$\begin{aligned} Restrictiveness_{iym} &= \gamma_1 \ln\left(1 + COVID_{iym}\right) + \gamma_2 \ln\left(1 + Vaccine_{iym}\right) \\ &+ \gamma_3 \ln\left(1 + COVID_{iym}\right) \times \ln\left(1 + Vaccine_{iym}\right) + \delta_i + \delta_{ym} + \epsilon_{iym}, \end{aligned} \tag{2}$$

The dependent variable is an index on the strictness of "lockdown style" policies that primarily restrict people's behavior and lies in the range of 0 to 100. The higher index indicates that more restricted measures are effective. The data is drawn from Hale et al. (2021). Although the original data is available at a daily frequency, we computed for the simple average for each month. We estimated this equation for 180 countries from December 2020 to August 2021, when vaccination programs were ongoing.

The results are reported in Table 4. We clustered the standard errors by country, once again using the numbers of cases and deaths as a measure of COVID-19 damages. The coefficients for *COVID* and *Vaccine* are positively significant. The former result is natural, indicating that a larger number of confirmed cases or fatalities induce governments to introduce more restrictive orders. The interaction term between these two variables has significantly negative coefficients, as is consistent with our expectation. Namely, the effect of COVID-19 severity on the government's lockdown orders becomes smaller when the number of vaccination doses is larger, proving vaccinations as effective tools in their mitigating effect on the impact of COVID-19 severity on international trade.

=== Table 4 ===

5. Concluding Remarks

This paper empirically investigated how vaccinations change the effect of COVID-19 on trade. To do that, we examined the bilateral trade data among 31 countries from January 2019 to June 2021. As a result, we found that the negative effects of COVID-19 on trade are mitigated as the number of vaccination doses increases. Furthermore, we demonstrated that although confirmed cases/deaths of COVID-19 increase the restrictiveness of lockdown measures, this association becomes weaker when the number of vaccination doses is comparatively larger. Thus, the effect of vaccinations on lockdown orders would be the source of their mitigating effect on the impact of COVID-19 severity on international trade. These results naturally imply that the increase in vaccination doses will further increase international trade regardless of the number of confirmed cases or fatalities.

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Table 1. Baseline Results

	Export statistics		Import statistics	
	(I)	(II)	(III)	(IV)
ln (1 + Importer COVID)	−0.009***	−0.008***	−0.003	−0.004
	[0.002]	[0.002]	[0.003]	[0.003]
ln (1 + Exporter COVID)	−0.010***	−0.008***	−0.018***	−0.016***
	[0.003]	[0.003]	[0.003]	[0.003]
COVID	Case	Death	Case	Death
Number of observations	172,166	172,058	171,391	171,287
Pseudo R-squared	0.997	0.997	0.997	0.997

Notes: This table reports the estimation results obtained using the Poisson pseudo maximum likelihood (PPML) method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pair. In all specifications, we control for country pair–year fixed effects, country pair–month fixed effects, and year–month fixed effects.

Table 2. Poisson pseudo maximum likelihood (PPML) Estimation Results: Vaccine Interaction Terms

	Export statistics		Import statistics	
	(I)	(II)	(III)	(IV)
ln (1 + Imp. COVID)	−0.009***	−0.009***	−0.004	−0.005*
	[0.002]	[0.002]	[0.003]	[0.002]
ln (1 + Imp. Vaccine)	−0.007***	−0.003*	−0.011***	−0.005***
	[0.002]	[0.002]	[0.002]	[0.002]
ln (1 + Imp. COVID) * ln (1 + Imp. Vaccine)	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
ln (1 + Exp. COVID)	−0.012***	−0.010***	−0.019***	−0.017***
	[0.003]	[0.002]	[0.003]	[0.003]
ln (1 + Exp. Vaccine)	−0.013***	−0.007***	−0.004*	−0.002
	[0.002]	[0.002]	[0.002]	[0.001]
ln (1 + Exp. COVID) * ln (1 + Exp. Vaccine)	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
COVID	Case	Death	Case	Death
Number of observations	172,166	172,058	171,391	171,287
Pseudo R−squared	0.997	0.997	0.997	0.997

Notes: This table reports the estimation results obtained using the PPML method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pair. In all specifications, we control for country pair–year fixed effects, country pair–month fixed effects, and year–month fixed effects.

Table 3. Robustness Checks: Excluding China

	Export statistics		Import statistics	
	(I)	(II)	(III)	(IV)
ln (1 + Imp. COVID)	−0.004	−0.003	−0.006***	−0.007***
	[0.002]	[0.003]	[0.002]	[0.002]
ln (1 + Imp. Vaccine)	0.0000	0.0010	−0.006*	0.0000
	[0.004]	[0.003]	[0.003]	[0.003]
ln (1 + Imp. COVID) * ln (1 + Imp. Vaccine)	0.0000	0.0000	0.001**	0.0000
	[0.000]	[0.000]	[0.000]	[0.000]
ln (1 + Exp. COVID)	−0.010***	−0.011***	−0.009***	−0.004*
	[0.002]	[0.002]	[0.002]	[0.003]
ln (1 + Exp. Vaccine)	−0.016***	−0.011***	−0.012***	−0.010***
	[0.004]	[0.003]	[0.003]	[0.003]
ln (1 + Exp. COVID) * ln (1 + Exp. Vaccine)	0.001***	0.001***	0.001***	0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
COVID	Case	Death	Case	Death
Number of observations	165,446	165,342	164,742	164,642
Pseudo R−squared	0.996	0.996	0.996	0.996

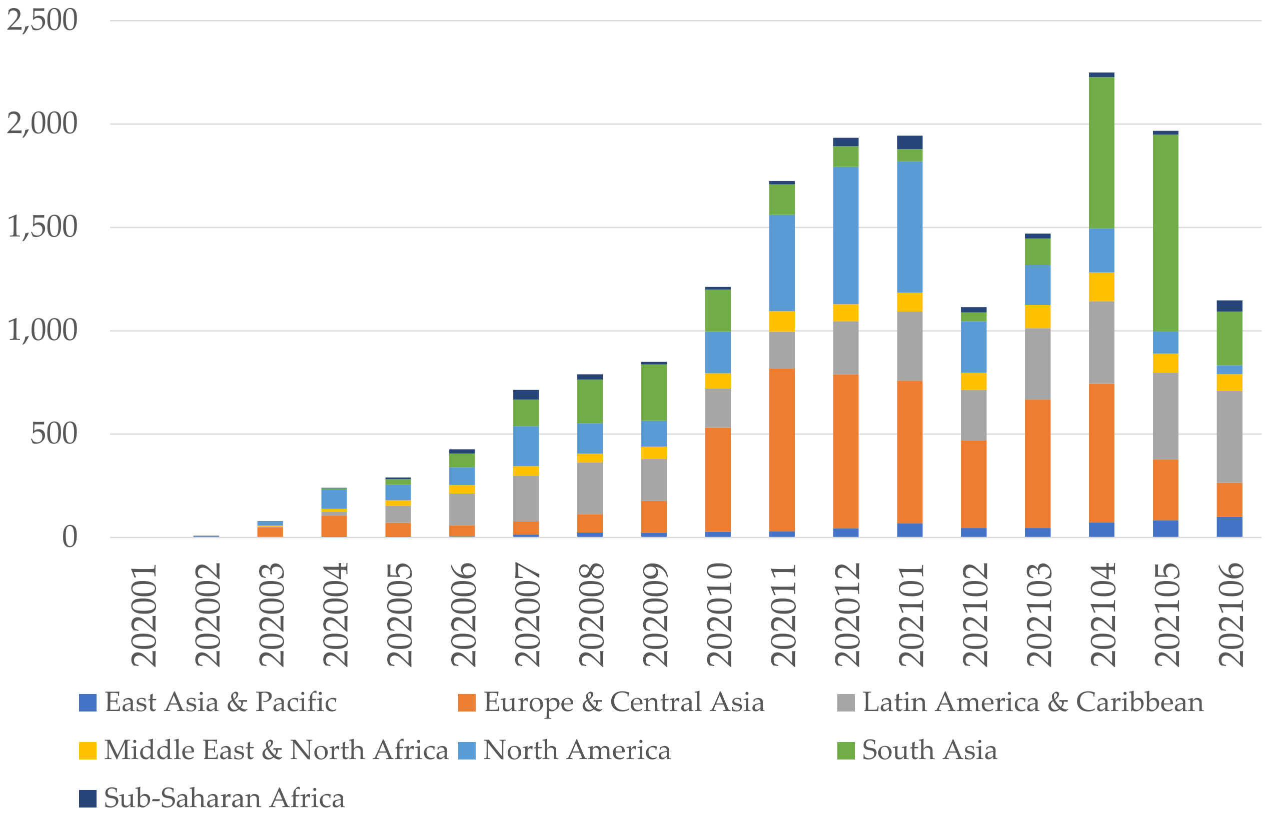
Notes: This table reports the estimation results obtained using the Poisson pseudo maximum likelihood (PPML) method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pair. In all specifications, we control for country pair–year fixed effects, country pair–month fixed effects, and year–month fixed effects.

Table 4. Regression of Stringency Index

	(I)	(II)
ln (1 + COVID)	3.937***	4.310***
	[0.390]	[0.407]
ln (1 + Vaccine)	0.972***	0.636***
	[0.259]	[0.190]
ln (1 + COVID) * ln (1 + Vaccine)	−0.055**	−0.048**
	[0.021]	[0.024]
COVID	Case	Death
Number of observations	1,589	1,589
Adjusted R−squared	0.76	0.772

Notes: The dependent variable is a stringency index. This table reports the estimation results obtained using the OLS method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pair. In both specifications, we control for country fixed effects and year–month fixed effects.

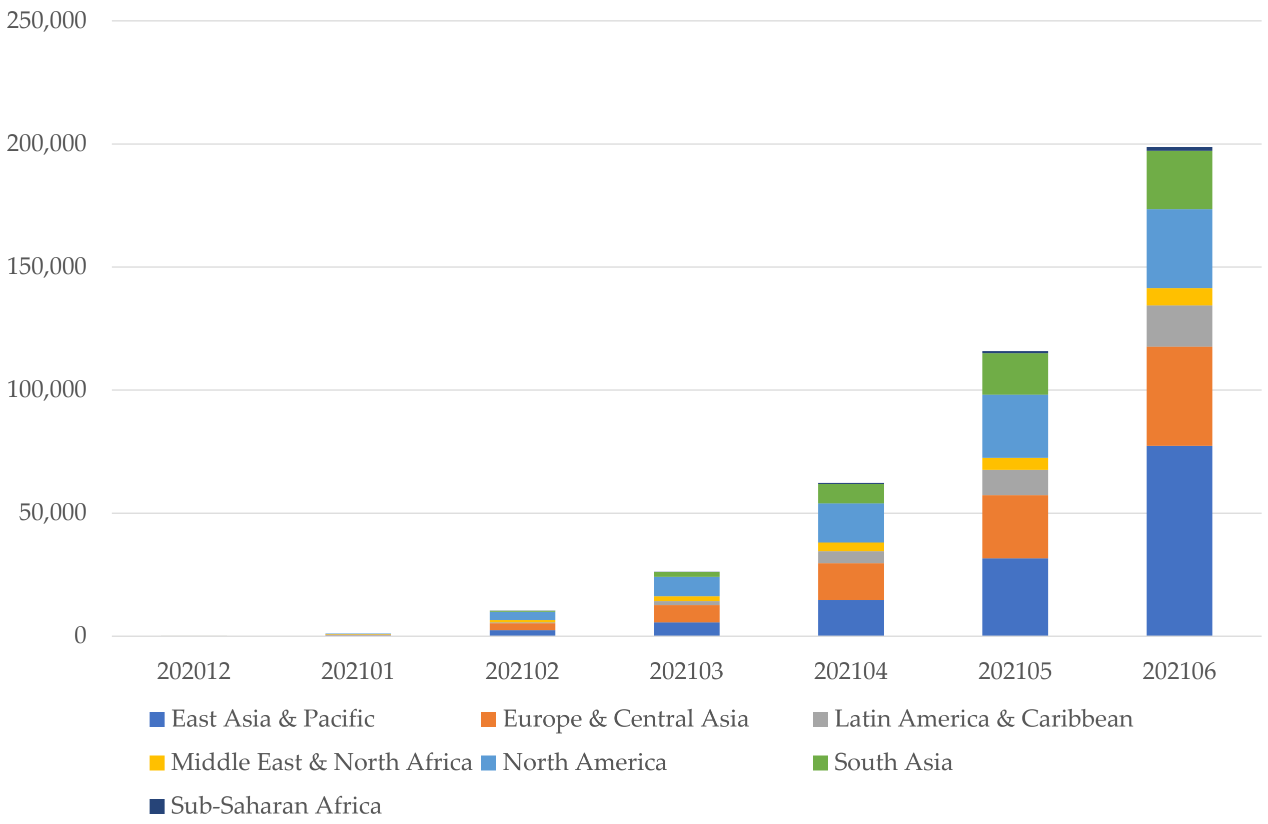
Figure 1. The Number of New Confirmed Cases of COVID-19 (Thousand persons)



Source: The COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

Note: This figure shows the aggregated number of monthly new confirmed cases of COVID-19 by region.

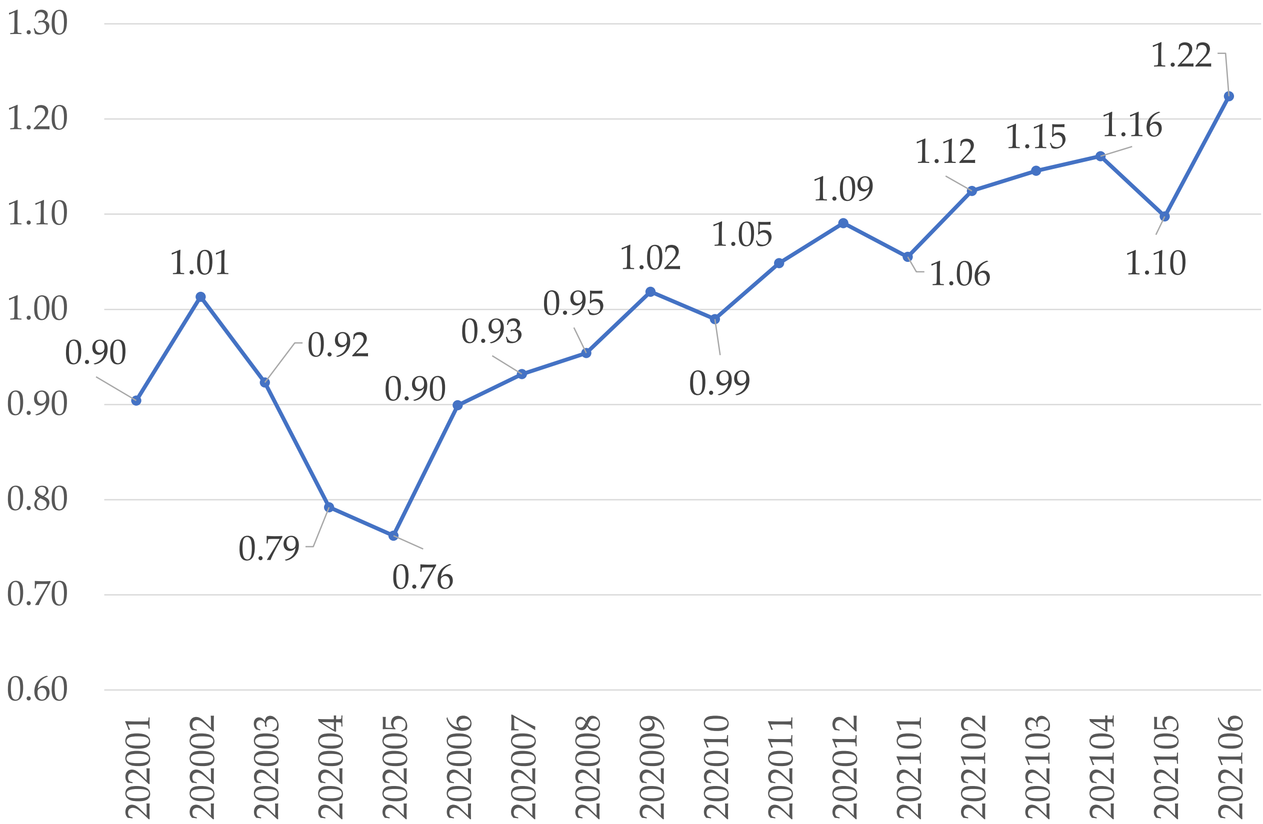
Figure 2. The Cumulative Number of Vaccine Doses (Thousand doses)



Source: The COVID-19 Data Repository by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

Note: This figure shows the cumulative number of COVID-19 vaccine doses administered as of the beginning of each month.

Figure 3. Evolution of the World Trade (relative to values in the corresponding month in 2019)



Source: Global Trade Atlas.

Appendix A. Study Countries (3-letter code)

31 reporting countries

ARG, AUS, BRA, CAN, CHE, CHN, CIV, DEU, ESP, FRA, GBR, GRC, HKG, IDN, IND, IRL, ISR, JPN, KEN, KOR, MEX, MYS, NZL, PRT, RUS, SGP, THA, TWN, USA, VNM, ZAF

220 partner countries

ABW, AFG, AGO, AIA, ALB, AND, ARE, ARG, ARM, ATF, ATG, AUS, AUT, AZE, BDI, BEL, BEN, BFA, BGD, BGR, BHR, BHS, BIH, BLR, BLZ, BMU, BOL, BRA, BRB, BRN, BTN, BWA, CAF, CAN, CCK, CHE, CHL, CHN, CIV, CMR, COG, COK, COL, COM, CPV, CRI, CUB, CXR, CYM, CYP, CZE, DEU, DJI, DMA, DNK, DOM, DZA, ECU, EGY, ERI, ESH, ESP, EST, ETH, FIN, FJI, FLK, FRA, FRO, FSM, GAB, GBR, GEO, GHA, GIB, GIN, GLP, GMB, GNB, GNQ, GRC, GRD, GRL, GTM, GUF, GUY, HKG, HND, HRV, HTI, HUN, IDN, IND, IRL, IRN, IRQ, ISL, ISR, ITA, JAM, JOR, JPN, KAZ, KEN, KGZ, KHM, KIR, KNA, KOR, KWT, LAO, LBN, LBR, LBY, LCA, LKA, LSO, LTU, LUX, LVA, MAC, MAR, MDA, MDG, MDV, MEX, MHL, MKD, MLI, MLT, MMR, MNG, MNP, MOZ, MRT, MSR, MTQ, MUS, MWI, MYS, NAM, NCL, NER, NFK, NGA, NIC, NIU, NLD, NOR, NPL, NRU, NZL, OMN, PAK, PAL, PAN, PCN, PER, PHL, PLW, PNG, POL, PRI, PRK, PRT, PRY, QAT, REU, ROM, RUS, RWA, SAU, SDN, SEN, SGP, SHN, SLB, SLE, SLV, SMR, SOM, SPM, STP, SUR, SVK, SVN, SWE, SWZ, SYC, SYR, TCA, TCD, TGO, THA, TJK, TKL, TKM, TON, TTO, TUN, TUR, TUV, TWN, TZA, UGA, UKR, URY, USA, UZB, VCT, VEN, VGB, VNM, VUT, WLF, WSM, YEM, ZAF, ZMB, ZWE

Appendix B. Other Estimation Results

Table B1. Poisson pseudo maximum likelihood (PPML) Estimation Results: No Interaction Terms

	Export statistics		Import statistics	
	(I)	(II)	(III)	(IV)
ln (1 + Importer COVID)	−0.009***	−0.008***	−0.003	−0.004
	[0.002]	[0.002]	[0.003]	[0.003]
ln (1 + Importer Vaccine)	0.0020	0.0020	−0.001	−0.001
	[0.001]	[0.001]	[0.001]	[0.001]
ln (1 + Exporter COVID)	−0.010***	−0.008***	−0.018***	−0.016***
	[0.003]	[0.003]	[0.003]	[0.003]
ln (1 + Exporter Vaccine)	0.000	−0.001	0.004***	0.004***
	[0.001]	[0.001]	[0.001]	[0.001]
COVID	Case	Death	Case	Death
Number of observations	172,166	172,058	171,391	171,287
Pseudo R−squared	0.997	0.997	0.997	0.997

Notes: This table reports the estimation results obtained using the PPML method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pair. In all specifications, we control for country pair–year fixed effects, country pair–month fixed effects, and year–month fixed effects.

Table B2. Poisson pseudo maximum likelihood (PPML) Estimation Results by Industry

	Importer			Exporter		
	Case	Vaccine	Cross	Case	Vaccine	Cross
Live animals	−0.004	−0.033***	0.002***	−0.007*	0.000	0.000
Vegetable products	−0.020*	−0.016	0.001	0.009	−0.017**	0.003***
Animal/vegetable fats and oils	−0.009	−0.003	0.000	0.006	0.017	−0.002
Food products	−0.008**	0.005	0.000	0.011***	−0.010**	0.000
Mineral products	−0.024***	−0.001	0.001	−0.002	−0.027***	0.002***
Chemical products	−0.001	−0.005	0.001**	0.003	0.001	0.000
Plastics and rubber	−0.013***	−0.012***	0.001***	−0.004	−0.012***	0.001***
Leather products	−0.034***	0.003	0.001	−0.001	−0.015***	0.002***
Wood products	−0.008*	−0.01	0.001**	−0.002	−0.017***	0.001***
Paper products	−0.004	−0.010***	0.001**	0.010*	−0.016***	0.001***
Textiles and apparels	−0.010***	0.006	0.000	0.002	−0.028***	0.002***
Footwear	−0.020***	−0.013**	0.001**	−0.006	−0.009*	0.001***
Plastic or glass products	−0.012***	−0.012***	0.001***	0.000	−0.014***	0.001***
Precious metals	0.03	0.044*	−0.005***	−0.022	−0.013	0.002
Base Metal	−0.014***	−0.016***	0.001***	0.004	−0.012***	0.001***
Machinery	−0.008***	−0.010***	0.001***	−0.013***	−0.008***	0.001***
Transport equipment	−0.023***	0.000	0.001	−0.030***	−0.019	0.001
Precision machinery	−0.013***	−0.012***	0.001***	−0.008***	−0.013***	0.001***
Miscellaneous	0.003	−0.006	0.000	−0.028***	−0.001	0.000

Notes: This table reports the estimation results obtained using the PPML method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. The statistical significance is based on the test using the standard errors clustered by country pair. In all specifications, we control for country pair–year fixed effects, country pair–month fixed effects, and year–month fixed effects. "*Case*" and "*Vaccine*" indicates the number of confirmed cases and the cumulative number of vaccine doses, respectively. "Cross" represents the interaction term between *Case* and *Vaccine*.