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Keywords: COVID-19; International Trade; China
JEL Classification: F15; F61; I18

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Heterogeneous Impacts of COVID-19 on Trade: Evidence from China's Province-level Data[§]

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Abstract: This study investigates how the extent of COVID-19 damage affected China's province-level trade with foreign countries and reports the heterogeneous effects of these damages. Using monthly trade data for January–August 2019 and 2020 and the number of confirmed COVID-19 cases, in a gravity equation, we measure the damage extent on exports and imports separately. The results show that a provincial rise in the confirmed cases decreases exports and imports, especially until March. The larger negative effects of COVID-19 are more prominent on the processing than ordinary trade; these effects are smaller in provinces with a larger number of deaths during the severe acute respiratory syndrome outbreak. However, urbanization and mobile phone diffusion exhibit a potential to mitigate these effects on trade.

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1. Introduction

The coronavirus disease 2019 (hereafter, COVID-19) pandemic has caused an unprecedented shock to the world economy. It was first identified in Wuhan, and the local government imposed restrictive measures, including the lockdown of Wuhan on 23 January, in an effort to arrest the rapid spread of the coronavirus. Nevertheless, the pandemic spread to all provinces of mainland China by 29 January, driving all these provinces to initiate the highest public response level to the pandemic. These responses included the extension of the 2020 Spring Festival holiday, the postponement of the new spring semester and various

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public events, and the implementation of lockdown and curfew in cities, villages, residential communities, and work units. The spread of the pandemic to the United States of America, the European Union, Japan, South Korea, and other countries, in mid-March, led these countries to take similar restrictive measures. These measures have significantly influenced the world economy.

In this context, we empirically investigate how the extent of COVID-19 damages affected China's province-level trade with foreign countries. We measure the extent of those damages by the number of confirmed COVID-19 cases, given that a rise and fall in this number have influenced the economic conditions since the outbreak. By employing the monthly trade data from January to August 2019 and 2020, respectively, we estimate the gravity equation with the number of confirmed cases for exports and imports separately. We focus on the effects of the pandemic in China by controlling for those effects in foreign countries using various fixed effects. We also examine the heterogeneous effects of COVID-19 from various dimensions—trade types (e.g., processing trade), provincial characteristics (e.g., urbanization), and industries. We also conduct different robustness checks, including the use of the number of COVID-19 deaths instead of that of the confirmed cases.

Our major findings are summarized as follows. First, the rise in the provincial number of confirmed cases of COVID-19 decreases both exports and imports, especially until March. Owing to China's restrictive measures, since March 2020, there has been a significant decline in the number of new cases and deaths. Second, the larger negative effects of COVID-19 were more prominent on the processing than ordinary trade. This finding may be attributed to the labor-intensive nature of the processing trade and its concentration in the severely affected provinces. Third, the negative effects of COVID-19 on trade were smaller in provinces with a larger number of deaths during the severe acute respiratory syndrome (SARS) outbreak. Fourth, urbanization and the diffusion of mobile phones played a role in mitigating the negative effects of COVID-19 on trade. This result may suggest an important role of the information technology (IT). Finally, the negative effects on trade exist only in some specific industries.

Our study contributes to the literature on the international trade-COVID-19 nexus.[1] Fuchs et al. (2020) addressed the trade pattern of critical medical goods, by using China's export data. Specifically, they empirically investigated whether the past political relationships as well as the economic ties with trade and investment partners influenced China's export pattern of critical medical goods during the first 2 months of the pandemic. Hayakawa and Mukunoki (2020a; 2020b) investigated trade among nearly 200 countries in the first half of 2020. Hayakawa and Mukunoki (2020a) showed that the exporting countries and those exporting machinery parts to the former witnessed a sharp decline in the exports of finished machinery products with the increasing severity of COVID-19. A similar study focused only on the Chinese trade (Friedt and Zhang 2020). Focusing on the United States

[1] Antras et al. (2020) provided the theoretical framework for this nexus.

of America, Meier and Pinto (2020) revealed that industries with an exposure to intermediate goods imports from China experienced a considerable drop in exports, imports, employment, and production. In regard to these effects, we provide evidence on the heterogeneous effects of the pandemic on trade according to various dimensions.

This study also adds new evidence to the literature on COVID-19 in China. As mentioned above, a few studies have examined the effects of COVID-19 on China's trade. Several studies have examined the effect of the lockdown policy on air pollution in China. Examples include Almond et al. (2020), Shi and Brasseur (2020), Chen et al. (2020), Cole et al. (2020), Wang et al. (2020), Fan et al. (2020), Kahn et al. (2020), and Pei et al. (2020). These studies found that lockdown orders contributed toward reducing air pollutants in China. George et al. (2020) focused on the epidemiological dynamics, that is, the transmission of diseases across countries and industries through supply chains. Based on China's and Association of Southeast Asian Nations' experience of the severe acute respiratory syndrome (SARS) and COVID-19, they determined the economic impacts of a pandemic that is associated with global production linkages. While Bu et al. (2020) examined people's risk-taking behavior in China during COVID-19, Fang et al. (2020) investigated the effects of Wuhan's lockdown policy on inter-city migration. Using a network approach, Luo and Tsang (2020) estimated the output loss owing to the lockdown of the Hubei province. Against this backdrop, we show the effects of COVID-19 on China's provincial trade.

The remainder of this paper is organized as follows. Section II provides an overview of COVID-19 and trade in China. After explaining the empirical framework in Section III, we report our estimation results in Section IV. Section V concludes this study.

2. Background

This section provides an overview of COVID-19 damages and trade in China. Figure 1 depicts the daily changes in the numbers of infection cases and deaths in China using the data collected by the Peking University Visualization and Visual Analytics Group.[2] The height of the crisis was in early and mid-February, with thousands of new cases and a large number of deaths reported per day. Afterward, however, owing to China's extremely restrictive measures, there was a significant decline in the number of new cases and deaths. Since March 6, 2020, while some days of April and July still saw more than 100 cases, the number of newly confirmed cases has been below 100 per day, and the pandemic has been successfully curtailed in mainland China. In summary, the duration of the peak effect of COVID-19 was short, that is, 1.5 months between January 23, 2020 (the lockdown of the Wuhan City) and March 6, 2020 (decline in the number of new cases to below 100 per day).

[2] https://vis.ucloud365.com/ncov/data_en.html

=== Figure 1 ===

Figure 2 shows the number of cases at the end of August by province. Hubei province (69,248), to which Wuhan belongs, accounted for 80% of the total cases in China (86,203). Guangdong Province reported the second largest number (1,740), followed by Henan Province (1,278), Zhejiang Province (1,270), and Hunan Province (1,019). The rest of the 26 provinces reported less than 1,000 cases, of which 52% (16 provinces) accounted for less than 500 cases. However, the most adversely affected regions were the Pearl River Delta region (Southern Guangdong Province) and the Yangtze River Delta region (Shanghai, Southern Jiangsu Province, and Northern Zhejiang Province)—China's two largest industrial centers. In short, the affected regions seem to have the highest industrial and trade concentration.

=== Figure 2 ===

Figure 3 shows the monthly changes in China's exports and imports in 2020 relative to those in 2019. The data on monthly level trade are drawn from the Global Trade Atlas maintained by the IHS Markit.[3] China's January 2020 data report the significant impacts of the COVID-19 pandemic on the international goods trade. The level of decline in exports and imports was higher in January 2020 than that in 2019. In particular, the exports experienced a 30% higher decline. In February, the amount of exports and imports returned to the pre-Covid level. These changes from January to February are partly attributed to the timing of the Chinese New Year, that is, the Chinese New Year fell in February in 2019 and in January in 2020. Thus, other things being equal, the trade values in 2020, relative to those in 2019, are likely to be smaller in January and larger in February. In March 2020, although there was a slight decline in both exports and imports, the exports started seeing a gradual rise from April. The imports decreased until May, after which it returned to the pre-Covid level.

=== Figure 3 ===

Figures 4 and 5, respectively, present the exports and imports from January to August 2020, relative to those for the corresponding period in 2019. We noted a relatively large decline in exports in the Tibet Autonomous Region, Qinghai Province, the Ningxia Hui Autonomous Region, and Gansu Province. Conversely, the level of exports was higher in 2020 than 2019 in Guizhou Province, Jiangxi Province, Sichuan Province, and Anhui Province. The imports witnessed a relatively large decline in the Ningxia Hui Autonomous Region, Qinghai Province, Guizhou Province, and Beijing. However, the level of imports

[3] https://connect.ihsmarkit.com/gta/home

was relatively high in the Xinjiang Uygur Autonomous Region, Sichuan Province, and Hebei Province.

=== Figures 4 & 5 ===

3. Empirical Framework

This section presents the empirical framework used to examine the effects of COVID-19 on China's trade. In particular, the lockdown policy adopted to prevent the spread of coronavirus played a key role in mitigating these effects. The stay-at-home order influenced the demand side of the economy. While stay-at-home orders were in effect, people were only allowed to go out to purchase essential supplies such as food, sanitation products, and medicine. However, large departmental stores and retail shops were closed, making it difficult to buy goods such as clothes, home appliances, and automobiles, which are not retailed at grocery stores. The decrease in sales due to workplace closures may have also reduced people's earnings and incomes, further decreasing the aggregate demand. These decreases in consumption opportunities and incomes contributed to the decline in the consumption of goods and their imports.

On the export side, the closure of workplaces halted business operations, which led to suspension of the production activities. Even factories that continued operations in exceptional cases found it difficult to maintain the pre-pandemic production levels. For example, there was a limit on the permissible number of employees for operations. This scenario also led to worker absenteeism caused by caregiving to children staying at home as a result of school closures. Since public transit was also stopped during the lockdown, workers commuting to work by public transport remained absent from work. The shortage of truck drivers and port laborers may have also delayed logistics and prevented the smooth procurement and delivery. Furthermore, there may have been a decline in productivity owing to the introduction of infection control measures (e.g., social distancing) in the factory. These factors resulted in shrinking the production output, and thus exports.

We empirically examined these effects on exports and imports by employing a model defined at a province-country-month-level. Our baseline equation is as follows:

$$Trade_{cpym} = \exp\{\beta \ln(1 + Cases_{pym}) + \delta_{cpy} + \delta_{cym} + \delta_{cpm}\} \cdot \epsilon_{cpym}$$

$Trade_{cpym}$ is the exports to or imports from country c in province p, in year y and month m. We measured the extent of COVID-19 damage by the number of confirmed cases, which is defined at a province-year-month-level. We used the sum of the new cases each month. While this number indicates the extent of physical damage, a large number of uninfected people also suffered the psychological impact of certain COVID-19 measures, the stringency of which normally increases with the number of new cases. Thus, we believe that both the physical and psychological impacts have been contributing towards the economic conditions in the COVID-19 era. In the later part of the analysis, we also use the number of deaths instead of that of the confirmed cases. We introduced various fixed effects, which are explained below. ϵ_{cpym} is a disturbance term. We estimated this equation using the Poisson pseudo maximum likelihood (PPML) method.

We controlled for three types of fixed effects. The country-province-year fixed effects (δ_{cpy}) control for the differences in various aspects at a country-province-level between the pre- and post-pandemic periods. These may include changes in the numbers of tourists or business visitors. Similarly, the country-province-month fixed effects (δ_{cpm}) control for the seasonality effects of trade in each country-province pair, including the seasonality of trade in fresh agricultural goods. Furthermore, a component of province fixed effects control for the differences in industry structures across provinces. The production and demand conditions in foreign countries are fully controlled by country-year-month fixed effects δ_{cym}. The production conditions include technology, factor prices, and supply capacity in foreign countries. Although the current pandemic has affected all the countries, we focus on the effects of the pandemic in China, by absorbing those effects in the rest of the world using the aforementioned fixed effect. Since δ_{cym} includes year-month fixed effects, it controls for the trade effects based on the difference in the timing of the Chinese New Year between 2019 and 2020.

There are some data issues. Our study covers the period January–August 2019 and 2020. Although there is ambiguity over the start date of the global spread, we believe that the situation did not trigger a health response in August 2019 as it did in the start of 2020. Hence, we set the number of confirmed cases in 2019 to zero. Our data sources for trade values and the number of cases are the same as those in Section II. Specifically, we obtained the monthly level trade data from the Global Trade Atlas maintained by the IHS Markit. We created balanced-panel data according to countries, provinces, years, and months, though some of the observations (i.e., singleton observations) were dropped owing to our inclusion of various fixed effects. We sampled 210 countries. The daily number of new cases was drawn from the data collected by the Peking University Visualization and Visual Analytics Group.

4. Empirical Results

This section reports our estimation results. We cluster the standard errors at a country-province-level. Columns (I) and (II) show the estimation results for provinces' exports and imports, respectively. We can see contrasting results in these columns. The coefficients are significantly positive and negative for exports and imports, respectively. Specifically, the provincial rise in the number of confirmed cases led to a decline in exports but increase in imports. This contrasting result remained unchanged even when we used the number of deaths, instead of the cases, as a measure, as shown in columns (III) and (IV). The absolute magnitude of the coefficients was slightly larger when using the number of deaths than when using the number of cases.

=== Table 1 ===

Next, we examined the differences in the effects according to months. After the extended Spring Festival holiday, on February 10, 2020, the central government allowed factories to resume operations. However, after the Spring Festival holiday, the workers could not return to their workplace immediately because of the quarantine measures. It must also be noted that, in most provinces, the lockdown orders were gradually lifted in late February and early March. Given these factors, the effects of COVID-19 on trade differs by month. To examine this difference, we interact the number of cases with the dummy variable on months by setting January as a base month. The results are presented in columns (I) and (II) in Table 2. In the case of both exports and imports, the coefficient for non-interacted cases is estimated to be significantly negative, indicating that the rise in the number of cases caused a decline in both exports and imports in January. However, all interaction terms with dummy variables on the months have significantly positive coefficients, implying a rapid decline in the negative effects on trade after January. Negative effects existed only until March. Since then, the effects have been almost zero or positive, especially in the case of imports. This difference across months yielded a positive coefficient in imports in column (II) in Table 1.[4]

=== Table 2 ===

We conducted two kinds of robustness checks on the results. First, for our analysis, we used the monthly trade data. Owing to the difference between the trade contract date and the departure/arrival date of goods at customs, the month in the number of cases may not correspond to that recorded in trade statistics. For example, goods that show up in the import statistics of June may be produced in exporting countries in May. To reduce the bias from this difference, we aggregated our data by 2 months. Specifically, since this study covers a period of 8 months, our data has four time-points in each year. The results are shown in Table 3. Columns (I) and (III) show significantly negative coefficients for the number of cases, in the case of both exports and imports. In columns (II) and (IV), we introduced the interaction terms with the dummy variables on the time-points. Although all variables have insignificant coefficients in imports, the results for exports are similar to those in column (I) in Table 2.

[4] The Appendix presents the results, which have been estimated using the number of deaths.

=== Table 3 ===

Second, we excluded the United States of America from our sample. There have been trade disputes between China and the United States since 2018. Both countries imposed additional tariff duties or trade restrictions on each other. In particular, these measures changed over the months, even during our study period. Although they seem to be uncorrelated with the number of cases, we safely dropped the United States of America from our sample and estimated the models. Table 4 presents the estimation results. We do not observe a significant decline in the number of observations, compared with those in Tables 1 and 2. Therefore, the results are similar to those in the previous tables. In other words, the negative effects on trade are largest in January, which decrease over the months.

=== Table 4 ===

Next, we examined the heterogeneous effects of COVID-19. In Table 5, we regressed the trade by type, including ordinary and processing trades.[5] These two types of trade comprise a major proportion of China's trade. Table 5 reports the estimation results. As in Table 1, the coefficients are negative for exports and positive for imports. In the case of exports, the negative effects are larger in processing than ordinary trade. In the case of imports, the positive magnitude of the coefficient is smaller in processing trade. In short, the processing trade suffers from the larger negative effects of COVID-19 than ordinary trade. This result may be attributed to the labor-intensive nature of the processing trade and its concentration in the severely affected provinces. These factors increase the cost of quarantine/preventive measures, and thereby hinder the recommencement of factory operations.

=== Table 5 ===

We further examined the heterogeneous effects on trade by interacting three variables with the number of cases. First, we introduced the interaction term with the number of deaths by SARS; it started in Southern China and evolved into an epidemic. In China, from November 2002 to July 2003, more than 5000 persons were infected and 350 persons died of SARS. Both COVID-19 and SARS are caused by coronaviruses. Owing to learning from this

[5] "Ordinary trade" includes trade with regimes of barter trade, donation by overseas Chinese, goods on consignment, goods on lease, and ordinary trade. "Processing trade" includes trade with regimes of compensation trade, entrepot trade by bonded area, equipment for processing trade, equipment imported into export process zones, outward processing, process and assembling, process with imported materials, and warehousing trade.

experience, the provinces hit more severely by the SARS may have more effectively managed the various challenges posed by COVID-19. Indeed, Hassan et al. (2020) found that firms with the SARS experience are more resilient to the COVID-19 crisis.[6] To examine whether the SARS experience mitigates the harmful effects of COVID-19 on trade, we introduced the interaction term of the number of COVID-19 cases with the total number of deaths by the SARS.[7] Columns (I) and (IV) show the results for exports and imports, respectively. Consistent with the expectation above, we found significantly positive coefficients for the interaction term between the COVID-19 cases and the SARS deaths. Thus, the negative effects of COVID-19 on trade are smaller in provinces with a larger number of deaths during the SARS outbreak.

=== Table 6 ===

Second, we introduced the interaction term with the share of the urban population in the total population, which indicates the degree of urbanization.[8] Columns (II) and (V) present the results and indicate that the coefficients for the interaction term are estimated to be significantly positive, in the case of both exports and imports. One of the reasons behind this mitigation effect is that IT networks are more developed in the urban than rural areas. In urban areas, economic activity is sustained through telecommuting systems, and people living in the urban areas mostly purchase their goods via e-commerce (EC) malls. To examine the role of IT more directly, as the third variable, we introduced the interaction term with the diffusion rates of mobile phones (i.e., the number of mobile phones per person), given that it is common in China to access the Internet via mobile phones.[9] Columns (III) and (VI) show the results with those interaction terms, which are again positively significant in the case of both exports and imports. Thus, IT development plays a role in mitigating the negative effects of COVID-19 on trade.

Finally, we estimated our models by industry, defined in the tariff section of the harmonized system. We reported the results of the coefficients for the number of cases in Table 7. We found the negative effects in the case of the exports of live animals, chemical products, footwear, plastic or glass products, precious metals, base metals, machinery, and transport equipment. Some of these industries require high labor force participation in production. Given this, we believe that the workplace-closing order may have led to a

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[6] Fernandes and Tang (2020) examined the effects of SARS on firm-level trade and found its significantly negative impacts.

[7] We obtain the data on the number of deaths by the SARS from the National Health Commission of China.

[8] The data on urban and total population by province are drawn from the China Statistical Yearbook 2019.

[9] We obtain the data on the number of mobile phones by the end of 2018 from Askci Corporation (www.askci.com).

decline in production and exports. Similarly, the negative effects on imports can be found in the case of plastics, rubber, and footwear. Conversely, we noted the positive effects in the case of the imports of live animals, textiles, precious metals, and machinery. The products like masks, apparel, and electronic machinery are typically purchased via EC malls; these frequent purchases via the EC may have increased the demand for these products, and thereby contributed to the aforementioned positive effects. Moreover, masks are also purchased directly in large quantities by factories, as part of their reopening process.

=== Table 7 ===

5. Concluding Remarks

This study empirically investigated how the number of COVID-19 cases affected China's province-level trade with foreign countries, by employing the monthly trade data from January to August in 2019 and 2020. We showed that the impacts of the COVID-19 pandemic on China's trade were different not only between imports and exports and across industries but also across provinces. By clarifying these heterogeneous impacts of COVID-19, our results suggest that policies aimed at mitigating the negative impacts of the pandemic on trade should be more targeted and nuanced, in contrast to the "one-size-fits-all" polices currently introduced in several countries. We also showed that the past experience of coronavirus mitigated the negative effects of COVID-19 on trade. Therefore, in order to remain prepared for a possible pandemic in the future, China must record the measures and interventions employed for managing COVID-19. In regard to minimizing these effects, we showed the positive role of IT in mitigating the negative effects on both exports and imports. Further development of the IT environment can contribute toward minimizing such negative effects on trade.

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Table 1. Baseline Estimation Results

	Export	Import	Export	Import
	(I)	(II)	(III)	(IV)
ln (1+Cases)	-0.019***	0.011*		
	[0.006]	[0.006]		
ln (1+Deaths)			-0.022**	0.038***
			[0.011]	[0.012]
No. of obs	79,666	51,384	79,666	51,384
Pseudo R-squared	0.9968	0.9923	0.9968	0.9923
Log pseudolikelihood	-2.6E+10	-4.7E+10	-2.6E+10	-4.7E+10

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

Table 2. Impacts of Infection Cases by Months

	(I)	(II)
Flow	Export	Import
ln (1+Cases)	-0.104***	-0.043**
	[0.014]	[0.017]
* D(Month=2)	0.065***	0.040**
	[0.015]	[0.017]
* D(Month=3)	0.070***	0.056***
	[0.014]	[0.020]
* D(Month=4)	0.103***	0.058**
	[0.019]	[0.023]
* D(Month=5)	0.102***	0.066***
	[0.017]	[0.022]
* D(Month=6)	0.085***	0.060***
	[0.014]	[0.019]
* D(Month=7)	0.115***	0.057***
	[0.016]	[0.020]
* D(Month=8)	0.101***	0.052**
	[0.015]	[0.021]
No. of obs	79,666	51,384
Pseudo R-squared	0.9968	0.9923
Log pseudolikelihood	-2.6E+10	-4.7E+10

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

Table 3. Robustness Check: Aggregation by 2 months

Flow	Export		Import	
	(I)	(II)	(III)	(IV)
ln (1+Cases)	-0.030***	-0.068***	-0.019***	-0.023
	[0.006]	[0.010]	[0.007]	[0.015]
* D(Month=3/4)		0.034***		-0.024
		[0.012]		[0.019]
* D(Month=5/6)		0.044***		0.013
		[0.012]		[0.016]
* D(Month=7/8)		0.056***		0.011
		[0.013]		[0.017]
No. of obs	41,070	41,070	26,828	26,828
Pseudo R-squared	0.9981	0.9982	0.9959	0.996
Log pseudolikelihood	-1.5E+10	-1.5E+10	-2.5E+10	-2.5E+10

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

Table 4. Robustness Check: Excluding the United States of America

Flow	Export		Import	
	(I)	(II)	(III)	(IV)
ln (1+Cases)	-0.019***	-0.096***	0.010*	-0.031*
	[0.006]	[0.014]	[0.006]	[0.017]
* D(Month=2)		0.061***		0.028
		[0.015]		[0.018]
* D(Month=3)		0.065***		0.047**
		[0.014]		[0.020]
* D(Month=4)		0.101***		0.047**
		[0.020]		[0.023]
* D(Month=5)		0.084***		0.047**
		[0.017]		[0.020]
* D(Month=6)		0.076***		0.047**
		[0.015]		[0.019]
* D(Month=7)		0.098***		0.044**
		[0.014]		[0.019]
* D(Month=8)		0.093***		0.041*
		[0.015]		[0.021]
No. of obs	79,170	79,170	50,888	50,888
Pseudo R-squared	0.996	0.9961	0.9922	0.9922
Log pseudolikelihood	-2.5E+10	-2.4E+10	-4.5E+10	-4.5E+10

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

Table 5. Impacts of Infection Cases by Trade Types

Flow	Export		Import	
Type	Ordinary	Process	Ordinary	Process
	(I)	(II)	(III)	(IV)
ln (1+Cases)	-0.011**	-0.027***	0.013**	0.001
	[0.006]	[0.010]	[0.007]	[0.010]
No. of obs	77,768	47,964	46,876	28,952
Pseudo R-squared	0.9961	0.996	0.9889	0.9918
Log pseudolikelihood	-1.7E+10	-1.3E+10	-3.9E+10	-1.9E+10

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

Table 6. Heterogeneous Impacts of Infection Cases

Flow	Export			Import		
	(I)	(II)	(III)	(IV)	(V)	(VI)
ln (1+Cases)	-0.024***	-0.089***	-0.062***	-0.006	-0.047*	-0.032*
	[0.007]	[0.025]	[0.015]	[0.007]	[0.025]	[0.017]
* ln (1+SARS)	0.003**			0.005***		
	[0.001]			[0.001]		
* Urbanization		0.111***			0.085**	
		[0.035]			[0.038]	
* Cellphone			0.036***			0.032**
			[0.011]			[0.013]
No. of obs	79,666	79,666	79,666	51,384	51,384	51,384
Pseudo R-squared	0.9968	0.9968	0.9968	0.9923	0.9923	0.9923
Log pseudolikelihood	-2.6E+10	-2.6E+10	-2.6E+10	-4.7E+10	-4.7E+10	-4.7E+10

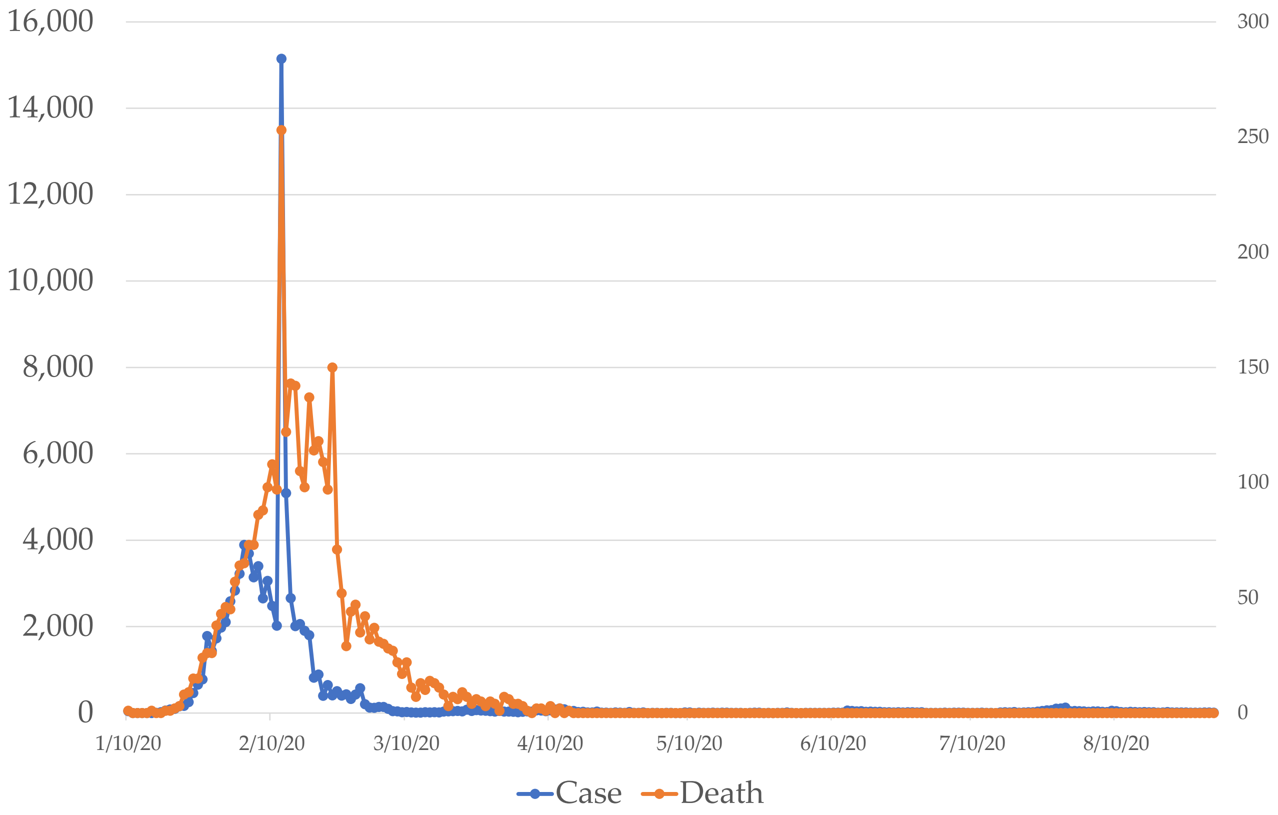
Notes: This table reports the estimation results using the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed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

Table 7. Impacts of Infection Cases by Tariff Sections

	Export		Import	
	Coef	S.E.	Coef	S.E.
Live animals	-0.021*	[0.012]	0.028*	[0.017]
Vegetable products	0.001	[0.015]	0.043	[0.049]
Animal/vegetable fats and oils	0.022	[0.069]	-0.032	[0.060]
Food products	-0.011	[0.008]	0.003	[0.012]
Mineral products	0.094***	[0.033]	0.015	[0.013]
Chemical products	-0.037***	[0.008]	-0.003	[0.013]
Plastics and rubber	0.002	[0.007]	-0.019**	[0.008]
Leather products	0.006	[0.018]	0.013	[0.018]
Wood products	0.002	[0.007]	-0.015	[0.021]
Paper products	-0.016	[0.013]	0.012	[0.017]
Textiles	-0.002	[0.012]	0.035***	[0.011]
Footwear	-0.028*	[0.016]	-0.048*	[0.027]
Plastic or glass products	-0.048***	[0.014]	0.007	[0.018]
Precious metals	-0.115**	[0.047]	0.247*	[0.134]
Base Metal	-0.019**	[0.007]	-0.008	[0.016]
Machinery	-0.022***	[0.007]	0.017**	[0.008]
Transport equipment	-0.061**	[0.026]	0.002	[0.032]
Precision machinery	-0.009	[0.011]	-0.001	[0.009]
Miscellaneous	-0.015	[0.015]	0.029	[0.034]

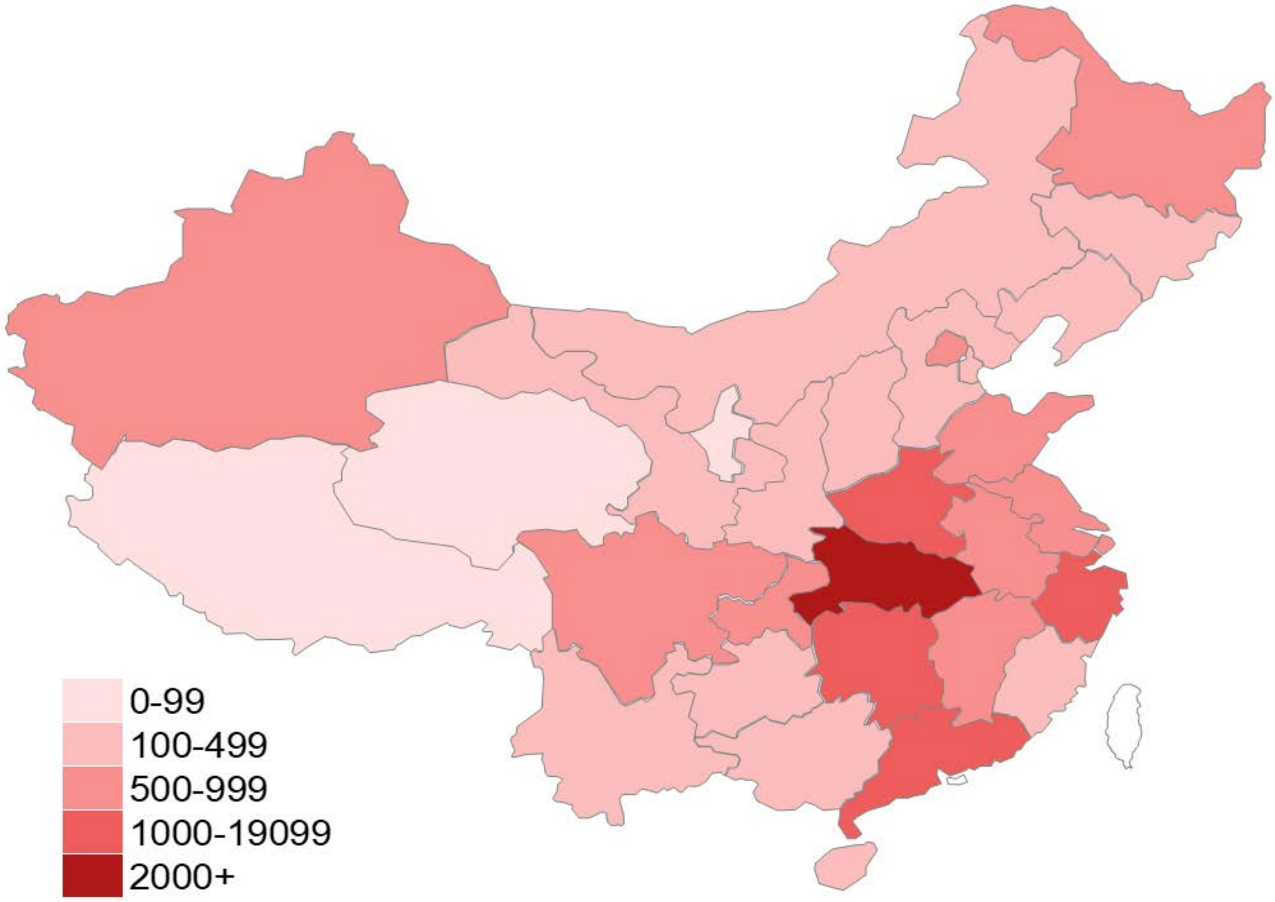
Notes: This table reports the estimation results using the PPML method. ***, **, and * indicate 1%, 5%, and 10% levels of statistical significance, respectively. The standard errors reported in parentheses are those clustered by country pairs. In all specifications, we control for country-pair fixed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

Figure 1. The Numbers of Infection Cases (Left) and Deaths (Right) in China



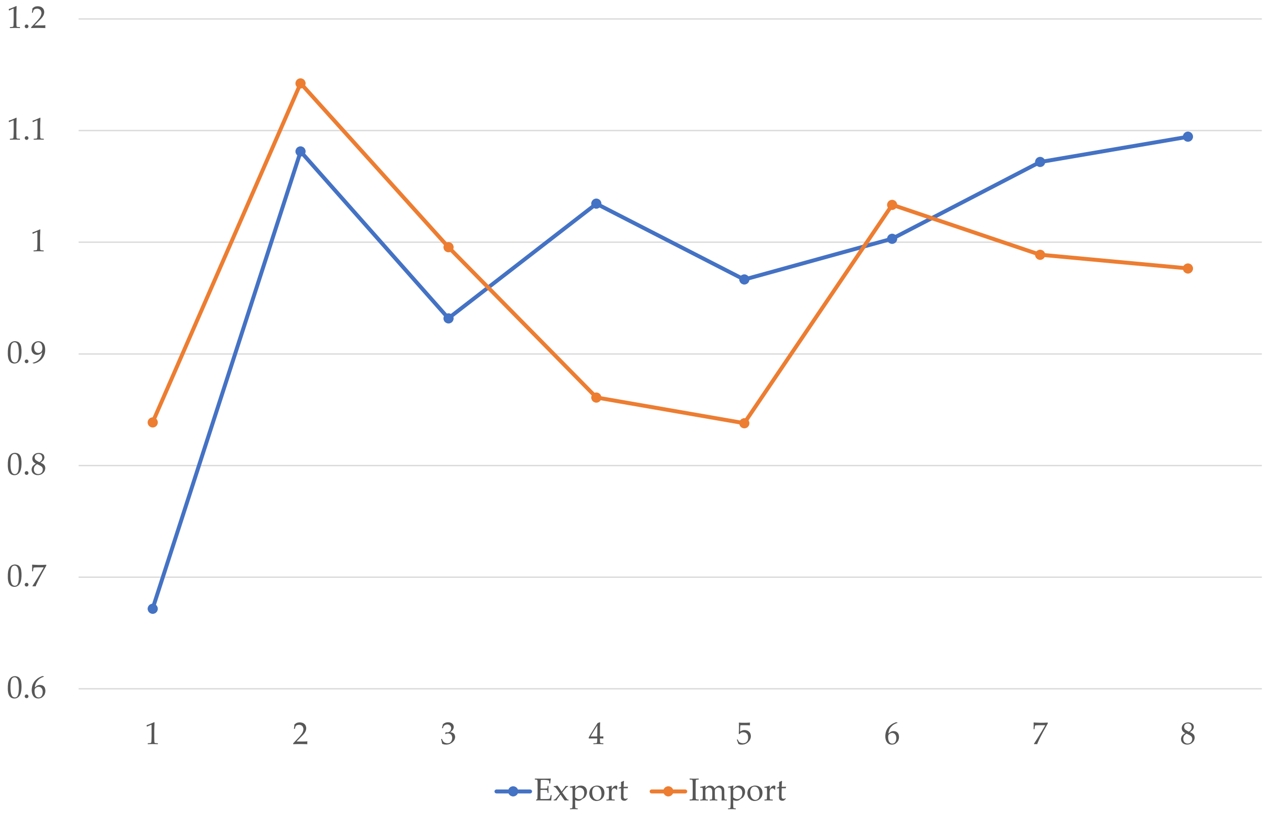
Source: Dataset of Newly Confirmed Cases of COVID-19 in China, prepared by Peking University Visualization and Visual Analytics Group, available at https://vis.ucloud365.com/ncov/data_en.html

Figure 2. The Number of Infection Cases as of the end of August by Province



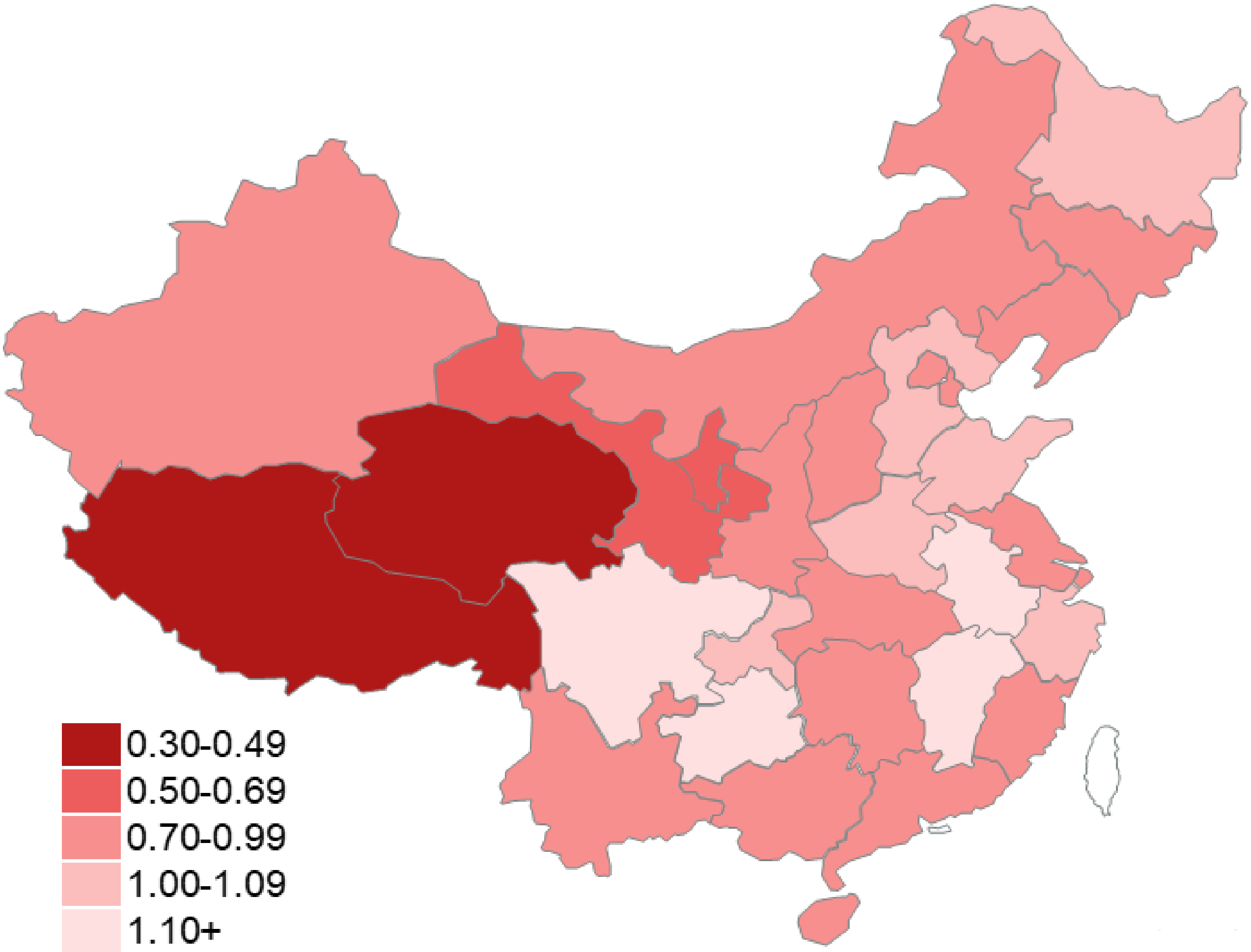
Source: Dataset of Newly Confirmed Cases of COVID-19 in China, prepared by Peking University Visualization and Visual Analytics Group, available at https://vis.ucloud365.com/ncov/data_en.html

Figure 3. Monthly Trade in 2020 Relative to Trade in 2019



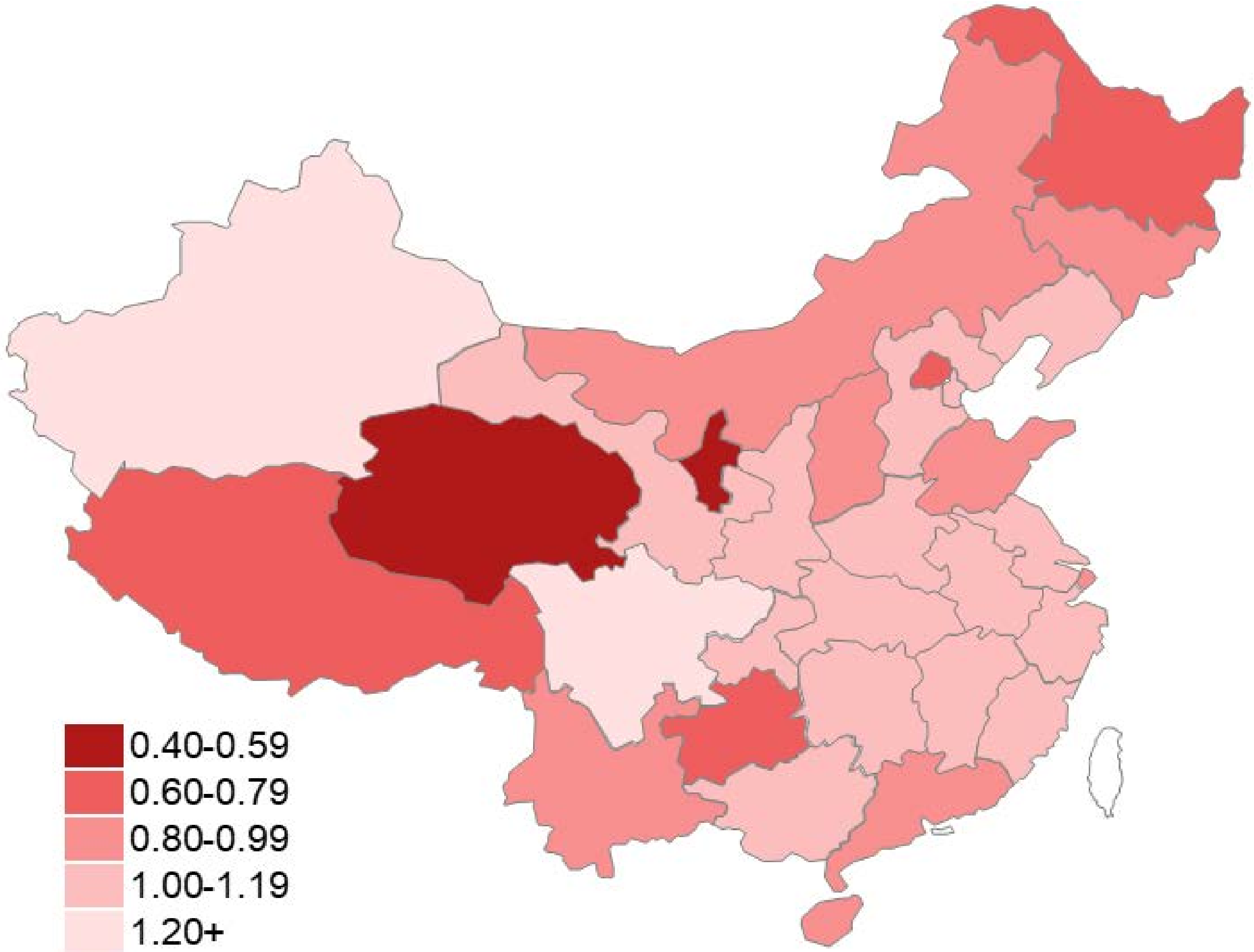
Source: Global Trade Atlas by IHS Markit.

Figure 4. Exports in January to August 2020 Relative to those in January to August 2019



Source: Global Trade Atlas by IHS Markit.

Figure 5. Imports in January to August 2020 Relative to those in January to August 2019



Source: Global Trade Atlas by IHS Markit.

Appendix. Other Estimation Results.

Table A1. Impacts of Deaths by Months

	(I)	(II)
Flow	Export	Import
ln (1+Deaths)	0.024	0.073***
	[0.018]	[0.025]
* D(Month=2)	-0.030**	-0.033
	[0.014]	[0.025]
* D(Month=3)	-0.122***	-0.062*
	[0.015]	[0.032]
* D(Month=4)	0.026	-0.031
	[0.024]	[0.047]
No. of obs	79,666	51,384
Pseudo R-squared	0.9968	0.9923
Log pseudolikelihood	-2.6E+10	-4.7E+10

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

Table A2. Impacts of Deaths by Trade Types

Flow	Export		Import	
Type	Ordinary	Process	Ordinary	Process
	(I)	(II)	(III)	(IV)
ln (1+Deaths)	-0.045***	0.006	0.044***	0.018
	[0.008]	[0.021]	[0.014]	[0.020]
No. of obs	77,768	47,964	46,876	28,952
Pseudo R-squared	0.9961	0.996	0.9889	0.9918
Log pseudolikelihood	-1.7E+10	-1.3E+10	-3.9E+10	-1.9E+10

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

Table A3. Heterogeneous Impacts of Deaths

Flow	Export			Import		
	(I)	(II)	(III)	(IV)	(V)	(VI)
ln (1+Deaths)	-0.053***	-0.443***	-0.316***	0.015	-0.085	-0.073**
	[0.009]	[0.056]	[0.032]	[0.013]	[0.061]	[0.037]
* ln (1+SARS)	0.030***			0.016***		
	[0.005]			[0.005]		
* Urbanization		0.656***			0.181*	
		[0.088]			[0.095]	
* Cellphone			0.265***			0.091***
			[0.030]			[0.031]
No. of obs	79,666	79,666	79,666	51,384	51,384	51,384
Pseudo R-squared	0.9968	0.9968	0.9969	0.9923	0.9923	0.9923
Log pseudolikelihood	-2.6E+10	-2.6E+10	-2.5E+10	-4.7E+10	-4.7E+10	-4.7E+10

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

Table A4. Impacts of Deaths by Tariff Sections

	Export		Import	
	Coef	S.E.	Coef	S.E.
Live animals	-0.067**	[0.027]	0.041	[0.041]
Vegetable products	-0.04	[0.027]	0.15	[0.109]
Animal/vegetable fats and oils	-0.17	[0.105]	0.096	[0.121]
Food products	0.006	[0.025]	0.005	[0.034]
Mineral products	0.17	[0.105]	0.052	[0.035]
Chemical products	-0.023*	[0.013]	-0.015	[0.032]
Plastics and rubber	-0.027*	[0.015]	0.022	[0.019]
Leather products	-0.013	[0.034]	-0.049	[0.047]
Wood products	-0.033	[0.027]	0.014	[0.046]
Paper products	-0.119***	[0.021]	-0.003	[0.033]
Textiles	-0.100***	[0.015]	0.065**	[0.027]
Footwear	-0.095***	[0.016]	0.048	[0.047]
Plastic or glass products	-0.04	[0.026]	-0.012	[0.036]
Precious metals	0.148	[0.303]	-0.164	[0.146]
Base Metal	-0.023	[0.016]	-0.021	[0.030]
Machinery	-0.013	[0.012]	0.026	[0.018]
Transport equipment	0.097**	[0.039]	0.1	[0.069]
Precision machinery	-0.018	[0.022]	0.004	[0.019]
Miscellaneous	-0.005	[0.017]	-0.063	[0.040]

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