Front. Econ. China 2020, 15(4): 541–574
DOI 10.3868/s060-011-020-0023-7

RESEARCH ARTICLE

Yi Che [a], Weiqiang Liu [b], Yan Zhang [b], Lin Zhao [c]

China's Exports during the Global COVID-19 Pandemic

Abstract The global COVID-19 pandemic caused various economic contraction in most countries, including all of China's major trading partners. Using a difference-in-differences model, this study examines the impact of the COVID-19 pandemic on China's monthly exports from January 2019 to May 2020. We find strong and robust evidence that China's exports to countries at high risk from the pandemic experienced a larger decline than exports to low-risk countries after the onset of the pandemic, with the prices of exports increasing significantly. Furthermore, the results of a triple differences model show heterogeneous effects across different industries and goods. Chinese industries located upstream in the global value chain are more vulnerable than those located downstream. Industries with high labor and contract intensity (proxies for processing trade) experienced greater declines than other industries. Exports of goods with high import elasticity of substitution experienced higher prices and moderate volume losses due to the pandemic.

Keywords China's exports, COVID-19 pandemic, global value chain, processing exports, elasticity of substitution
JEL Classification F0, F1, L6

1 Introduction

COVID-19 broke out in Wuhan, China at the end of December 2019. The World

Received August 16, 2020

[a] Antai College of Economics and Management, Shanghai Jiao Tong University, Shanghai 200030, China
[b] School of Economics, Shanghai University of Finance and Economics (SUFE), Shanghai 200433, China
[c] Institute for Advanced Research, Shanghai University of Finance and Economics (SUFE), Shanghai 200433, China
E-mail: tccheyi@sjtu.edu.cn (Yi Che), mediocreman@126.com (Weiqiang Liu), zhang_yan@mail.shufe.edu.cn (Yan Zhang, corresponding author), zhao.lin@mail.shufe.edu.cn (Lin Zhao)

Health Organization (WHO) declared it the sixth "public health emergency of international concern" on January 30, 2020. In February, COVID-19 was concentrated mainly in China and a few Asian countries, including South Korea and Japan. Since March, China curbed the virus significantly, with only a few cases confirmed between the end of February and the end of June. In sharp contrast, COVID-19 spread successively to countries outside China, and evolved into a global pandemic. By the end of March, all of China's major exporting partners were hit hard by the pandemic, and the cumulative confirmed cases outside China reached more than 778,138, with 39,160 deaths,[1] which was nine times that of China during the same period. The number of cumulative confirmed cases increased by roughly four, eight, and 13 times by the end of April, May, and June, respectively (Figure 1). The COVID-19 pandemic caused the most severe economic contraction since the Great Depression in the 1930s (IMF World Economic Outlook, April 2020[2]).

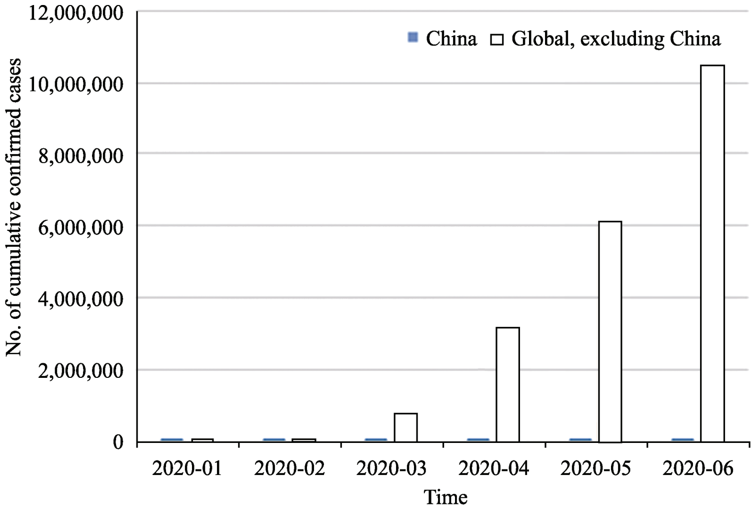

Figure 1 Cumulative Confirmed Cases, China vs. Others

Note: The data are from Johns Hopkins University (https://coronavirus.jhu.edu/map.html).

To prevent the spread of the pandemic, many countries conducted testing (Acemoglu et al., 2020), closed public facilities, and declared lockdown policies

[1] The data is from the statistics of Johns Hopkins University (https://coronavirus.jhu.edu/map.html).

[2] https://www.imf.org/en/publications/weo?page=2

that restricted supply capacity worldwide and drove up the cost of transport, logistics, and business travel. Furthermore, some countries implemented more stringent cross-border policies, such as stricter customs inspection and quarantine, suspension or closure of customs clearance of goods at border ports, and restrictions on transnational movement of people and goods. All these policies created significant barriers to China's exports. The statistics from China's General Administration of Customs show that China's exports, both in total and the year-on-year growth rate, declined sharply in February 2020 as China entered a lockdown. Moreover, China's exports continued to decline (both total exports and its growth rate are much lower than those in the same period in 2019) as its trade partners entered lockdowns, despite the easing of China's lockdown policies since March 2020.

The higher risk due to the COVID-19 pandemic potentially led to more stringent policies and hence a greater decline in China's exports. Figure 2 shows the negative correlation between the cumulative confirmed cases scaled by the population and the growth rate of China's exports to the country's 60 major export partners. To determine whether this time-series correlation is a causal impact and the size of the impact, we employ a difference-in-differences (DD) regression model to examine whether China's exports to high-risk countries experienced a greater decline compared with those to low-risk countries after the onset of the pandemic. We categorize high-risk countries by the number of cumulative confirmed cases scaled by total population. The key independent variable is equal to 1 if the risk is greater than the median and 0 otherwise. The cutoff point is the time after March 2020, when the WHO Director-General Tedros Adhanom Ghebreyesus declared COVID-19 a pandemic.[3] Our DD model allows us to eliminate a series of unobservable shocks that may mask a causal interpretation.

By comparing the China's exports to high-risk countries with those to low-risk countries before and after the onset of the pandemic, we find evidence that China's exports to high-risk countries decreased significantly and export prices increased significantly. The results are robust to several robustness checks, including alternative measures of pandemic risk, dropping the US from the sample, applying subsample analysis, and distinguishing between developed and

[3] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen

developing countries.

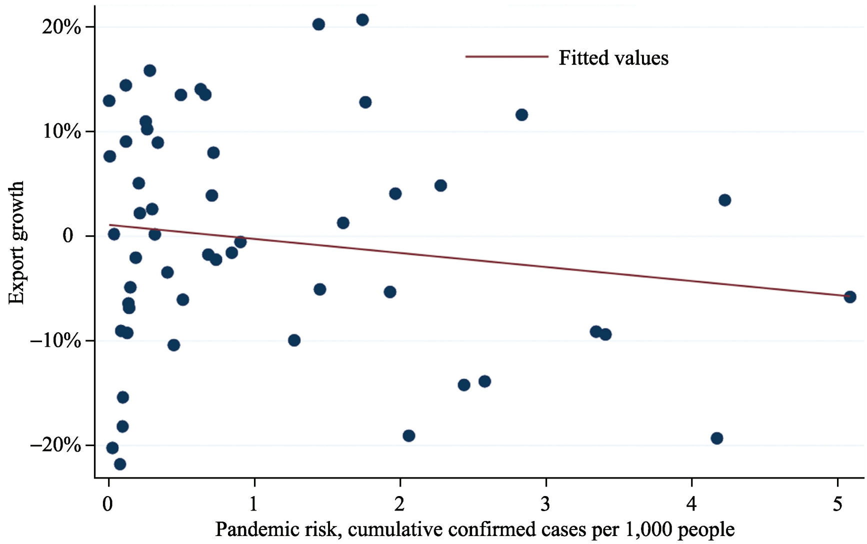

Figure 2 The Inverse Relationship between Export Growth and Pandemic Risk

Note: Export growth is the growth rate of total exports in March and April compared with the same period in the last year. Pandemic risk is the cumulative confirmed cases scaled by the population by the end of April. Among the 60 countries in the sample, Ireland, Kazakhstan, Luxembourg, Norway, Switzerland, Thailand, and Greece are dropped due to the abnormal Chinese export growth rate (higher than 25% or lower than 25%) to these countries.

Moreover, our heterogeneous analyses show that the effects of the COVID-19 pandemic on China's exports vary across industries and products. The global pandemic made it more difficult for exporters to cooperate with firms in the same industry in high-risk countries. It disrupted transnational trade networks, which might have driven the decrease in China's exports and increase in prices. We use the global value chain (GVC) position index (at the country-sector level) to identify China's position (upstream or downstream) in the global supply chain, and find that the pandemic had a greater effect on China's exports in upstream industries than those in downstream industries. This is likely because upstream goods participate in the GVC across multiple countries, and hence experienced significant effects of the pandemic.

In addition, we check the differing responses in processing and ordinary trade. Although the share of processing trade in China's total exports decreased in recent years (from 46.9% in 2010 to 29.4% in 2019[4]), it still contributes significantly to China's employment due to its high labor intensity. We could expect that the pandemic would affect processing exports more due to their high dependence on foreign markets and declining comparative advantage. Existing studies reveal that labor and contract intensity are crucial features of China's processing exports (Dai et al., 2016; Feenstra et al., 2013). Our heterogeneous analysis corroborates this finding and shows that processing exports suffered more from the pandemic and their prices increased significantly.

Due to differing pandemic risk and the corresponding policy responses across countries, the pandemic had varying effects on China's exports to different countries. Pandemic-induced trade barriers led to a decline in the global supply (outside China) of various products. Therefore, it was easier for China's exports with higher elasticity of substitution to grow their market shares or raise their export prices due to the production contraction among China's competitors, who are suffering from the spread of the pandemic. That is, theoretically, exports with high import elasticity of substitution may suffer less from the global pandemic. We investigate whether high elasticity of substitution over different sources of a product helped to stabilize China's exports during the pandemic. We use the import elasticity of substitution estimated at the Harmonized System (HS) 6-digit level from U.S. import data to capture the substitution between China's exports and exports from other countries. We find that export price (highly significant) and export value increase with the import elasticity of substitution. The results imply that the pandemic had heterogeneous impacts on products with various import elasticities of substitution, and high import elasticities of substitution helped to lower pandemic-induced export losses.

The literature investigating impacts of COVID-19 is emerging (e.g., Alfaro et al., 2020; Autor et al., 2020), considering its damage to our daily lives. Our study is closely related to the nascent literature investigating the effects of COVID-19 on trade (Baldwin and Mauro, 2020; Hassani and Shahwali, 2020; Maliszewska et al., 2020). However, our study differs from these studies by analyzing the effects of COVID-19 on trade from China's perspective, rather than applying a cross-country analysis. One exception in this stream of literature is Barua (2020), who also uses Chinese data for the same topic. However, Barua (2020)

---

[4] The statrstics is from China's Goneral Administration of Customs. The share of processing trade in China's total exports is calculated by the authors.

concentrates on the possible consequences for trade relations between China and the rest of the world. In addition, Barua (2020) focuses on the effects of the outbreak of COVID-19 in China, rather than the global pandemic since March. In contrast, we study the effects of the global pandemic after the situation in China was significantly controlled and analyze the impacts of the global pandemic from the perspective of China's exports.

The remainder of the paper proceeds as follows. Section 2 provides the background of the spread of the pandemic and prevention polices outside China. Section 3 presents the details of the identification strategy. Section 4 describes the data and variables. Section 5 reports the baseline results and the results of a battery of robustness checks. Section 6 discusses the heterogeneous effects. Section 7 concludes.

2 Background

The COVID-19 pandemic is a major cataclysmic event in the 21st century. Presumably, it not only disrupted the economies of countries hit hard by the pandemic, but also changed the distribution of economic power across countries. China outperformed other regions in dealing with the pandemic. According to a report by Rand,[5] one possible channel through which China had a surprisingly swift rise during the pandemic is international trade. Therefore, the extent to which the pandemic affected China's exports and how are of great concern.

According to the statistics of Johns Hopkins University, the COVID-19 pandemic hit[6] most countries since March 2020, although the time, duration, and patterns of the outbreak differ. COVID-19 broke out in Europe sequentially starting in March. The first country to suffer was Italy, where the daily new confirmed cases exceeded 1,000 on March 7, peaked in late March, and dropped below 1,000 by the middle of May. In Germany, France, and Spain, the daily new confirmed cases surpassed 1,000 per day in mid-March, a situation that persisted for nearly two months. The outbreak of the pandemic in the UK was relatively late (late March), but lasted for three months, which was much longer than in other European countries. By the end of March, the cumulative confirmed cases in Europe accounted for 53% of the global total.

[5] https://www.rand.org/pubs/research_reports/RR2798.html

[6] Here, "hit" means that there were more than 1000 new confirmed cases in a single day for a specific country.

The pandemic hit the US on March 10 and Brazil on March 31. Unlike in Europe, new confirmed cases in the US and Brazil experienced sustained growth and were still growing in August 2020. By April, the situation gradually improved in Europe, and the Americas replaced Europe as the most affected area worldwide. South Africa dominated the pandemic situation in Africa. Confirmed cases first appeared in South Africa in early March and broke out at the end of March. Similar to the Americas, the pandemic in South Africa persisted for a long time without any obvious decline in the number of confirmed cases by the end of May 2020.

The affected countries implemented comprehensive policies to curb the spread of the pandemic. In addition to some medical precautions, governments also implemented lockdown policies to reduce the spread of infections. For instance, with the rapid deterioration of the COVID-19 situation in the US, most states closed public facilities and declared lockdowns. In addition, several states, such as California, announced the closure of businesses, schools, and workplaces. These lockdown policies generally lasted more than 10 days and were extended for more than a month in most states (Moser and Yared, 2020). Moreover, major cities issued "stay in place" orders. In Europe, Italy was the first country to declare a nationwide lockdown: The government ordered all shops to close, except supermarkets, banks, pharmacies, post offices, and other necessary places. Thereafter, other countries such as Denmark, Ireland, Spain, and France also issued nationwide restrictions. Even Germany and the UK, which had no nationwide lockdown, issued some social segregation orders.

Many countries also implemented drastic cross-border policies in response to the pandemic. During their most severe periods, countries shut down their borders to nonresident foreigners and citizens returning from high-risk countries were forced to quarantine for 14 days. Customs inspections and quarantines were also much stricter, and some countries even suspended or closed customs clearance of goods at border ports. Approximately three billion people resided in countries that imposed complete border closures to foreigners.[7] These travel restrictions and border shutdowns made the transnational movement of people and goods more costly.

Policies aiming to curb the pandemic restricted supply capacity globally,

[7] The New York Times, "Coronavirus Travel Restrictions, across the Globe," July 16, 2020.

driving up the cost of transport, logistics, and business travel within and across countries and causing significant barriers to exports. As the world's largest exporter, China was deeply affected by the pandemic. According to statistics from China's General Administration of Customs,[8] cumulative total exports fell by 7.7% at the end of May.

3 Identification Strategy

To identify the causal impact of the COVID-19 pandemic on China's exports, we employ a DD framework. This framework allows us to compare the changes in exports between high-risk countries (treatment group) and low-risk countries (control group) before and after the outbreak of COVID-19.

Figure 2 displays the inverse relationship between China's export growth and pandemic risk measured by cumulative confirmed cases. The statistics reveal that countries with higher risk experience a greater decline in the growth of China's exports. This is probably because exports to these countries tend to have more pandemic-induced barriers, such as more costly logistics and more stringent customs clearance.

We conduct the DD analysis using the following estimating equation:

$$Export_{ijt} = \gamma_t + \delta_{ij} + \beta\left(Risk_j \times Post_t\right) + \varphi X_{ijt} + \varepsilon_{ijt}, \quad (1)$$

where $Export_{ijt}$ is China's exports of product *i* to country *j* at time *t*. $Risk_j$ is a dummy variable for the pandemic risk in country *j*, which equals 1 if the cumulative confirmed cases divided by total population in country *j* is greater than the median of all countries and 0 otherwise. $Post_t$ is a dummy, equal to 1 for March 2020 and beyond and 0 otherwise.[9] We chose March 2020 as our cutoff point because COVID-19 broke out globally in March 2020, and the WHO director-general Tedros Adhanom Ghebreyesus declared it a pandemic on March 11, 2020.

The coefficient of the interaction term (β) measures changes in China's exports to high-risk countries after the onset of the pandemic relative to low-risk countries. We expect the result to be negative. γ_t is a set of month fixed effects controlling all macro factors that may affect all exporters simultaneously. δ_{ij}

[8] http://www.customs.gov.cn/customs/302249/302274/302275/3114893/index.html
[9] For most of the 60 sample countries, confirmed cases began to appear sporadically at the beginning of March 2020.

denotes the product-country fixed effects, which controls for all characteristics that vary at the product and country levels (e.g., products designed specifically for one country's preference) and for the time-invariant country exporting capabilities and other factors related to product supply.

Following the gravity model (Head and Mayer, 2014), we control for a set of time-varying covariates, denoted with X_{ijt}, including the partners' demand, bilateral exchange rates, and tariffs. We represent demand from partner j by the annual growth rate of the industrial production index (IPI) of that country. We take the monthly averages of the bilateral exchange rates between China and its trading partners. The cost of trade is an important factor for exports (Chen and Voia, 2018), which we capture by the trading partners' import tariffs at the product level. The import tariffs for all partners remained unchanged during the sample period, except for the US, which adjusted its import tariffs on Chinese products several times during the sample period due to the ongoing China–US trade friction. To eliminate the impacts of the trade friction, U.S. import tariffs are time varying. We calculate them using the lists of Chinese goods subject to import tariffs published by the U.S. government during the sample period.

To investigate the heterogeneous effects further, we employ a triple differences (DDD) framework. The pertinent estimating equation is

$$\begin{aligned} Export_{ijt} = \gamma_t + \delta_{ij} + \beta_1 \left(F \times Risk_j \times Post_t\right) + \beta_2 \left(F \times Risk_j\right) \\ + \beta_3 \left(F \times Post_t\right) + \beta_4 \left(Risk_j \times Post_t\right) + \varphi X_{ijt} + \varepsilon_{ijt}, \end{aligned} \tag{2}$$

which uses the same variables as in equation (1), except the triple interaction term and inclusion of pertinent controls. F denotes the factors of interest that we use for the triple difference term, including the GVC position index, labor intensity, contract intensity, and import elasticity of substitution.

4 Data and Variables

We sourced the data for this study from several sources. The bilateral export data between China and its partners are from the statistics of China's General Administration of Customs, which records the value and quantities of exports and imports by source country at the HS 8-digit level. Export prices or unit values are the value divided by quantity at the HS 6-digit level (natural logarithm). We chose 60 major trading partners of China for the sample (January 2019 to May 2020), including all the countries from the Organisation for

Economic Co-operation and Development (OECD); major emerging economies such as Brazil, India, and South Africa; and major Southeast Asian countries. These partners accounted for 86% of China's total exports in 2019. In contrast to other exports, exports of medical supplies increased greatly with the global spread of the pandemic. To eliminate the impact of the high rise in exports of medical supplies, we excluded all medical supplies from our sample. We provided details on medical supplies in Table A8 in the appendix.

We obtained the cumulative number of confirmed cases of COVID-19 in each country from Johns Hopkins University (https://coronavirus.jhu.edu/map.html). We measured each country's risk by the share of cumulative confirmed cases in the total population (World Development Indicators). Our primary independent variable is a dummy that equals 1 if this share is greater than the sample median and 0 otherwise. As robustness checks, we also implemented two alternative key measures: a continuous measure of the cumulative confirmed cases divided by the country population and a dummy that equals 1 if the cumulative number of confirmed cases is greater than the sample median and 0 otherwise.

We constructed our measure of bilateral tariffs using the applied most favored nation tariffs between China and its trading partners from the World Trade Organization website. All partners' import tariffs remained unchanged during the sample period, except for the US. Therefore, we adopted time-varying U.S. import tariffs using the lists of Chinese goods subject to import tariffs published by the U.S. government during the sample period.

The bilateral exchange rate is the average exchange rate between China and its partners obtained from the Pacific Exchange Rate Service provided by the Sauder School of Business at the University of British Columbia (http://fx.sauder.ubc.ca/). We obtained the annual growth rate of the IPI for the OECD countries from OECD Statistics and the national statistical offices for the non-OECD countries. For Indonesia, for which IPI data are not available, we employed the manufacturing production index.

Following Koopman et al. (2010), we calculated the GVC position and participation index as follows:

$$GVC\_Position_{jk} = \ln\left(1 + \frac{IV_{jk}}{E_{jk}}\right) - \ln\left(1 + \frac{FV_{jk}}{E_{jk}}\right), \tag{3}$$

$$GVC\_Participation_{jk} = \frac{IV_{jk}}{E_{jk}} + \frac{FV_{jk}}{E_{jk}}, \tag{4}$$

where IV_{jk}, FV_{jk}, and E_{jk} are domestic value-added in the intermediate exports used by the direct importer to produce goods for third countries (indirect value added), foreign value added used in exports, and total exports, respectively. We obtained the data for these from the Trade in Value Added (TiVA) database. The subscripts j and k indicate the country and industry, respectively. $GVC\_Position_{jk} > 0$ implies that country j (a partner of China) lies upstream of industry k in the GVC and tends to export raw materials. $GVC\_Position_{jk} < 0$ implies that the country tends to export more final goods. Using the concordance table from the World Integrated Trade Solution database, we matched the GVC industries to the International Standard Industrial Classification (ISIC) statistical standard (version 3) and then the 6-digit HS (version 2017) for the analysis.

We constructed industry-level labor intensity using the percentage of workers without a four-year college education or above in an industry (Ciccone and Papaioannou, 2009). We calculated industry-level contract intensity as the proportion of intermediate inputs that require relationship-specific investments in the final good production (Nunn, 2007). Here, labor and contract intensity are measured at the ISIC level and are further matched to the HS 6-digit level.

We used the elasticities of substitution to identify the substitutability of exports among different countries, which we assumed are constant across countries for each traded good (at the HS 6-digit level). We measured the elasticities of substitution as the elasticities of substitution of U.S. imports, considering that there are more varieties of U.S. imports compared with other countries over the past decades. We calculated the elasticities based on Feenstra’s (1994) methodology and estimated them using the generalized method of moments (GMM) as in Broda et al. (2008). Our data come from the Comtrade database, which provides statistics on bilateral imports at the HS 6-digit level.

5 Estimation Results

In this section, we report the DD estimates of the effects of the global spread of COVID-19 on China’s exports and the results of several robustness checks. All standard errors are robust and clustered at the product level to allow for an arbitrary variance-covariance matrix within each product over time.

5.1 Baseline Results

The parallel trends assumption is the essential identification assumption in the DD model. That is, we assume that China's exports to its partners followed the same time trend in high- and low-risk countries before the global pandemic and after its onset. This assumption ensures that the coefficient of the interaction term reflects the effects of the pandemic on China's exports. Therefore, we first report the time trends of the natural logarithm of the value of China's exports to high-risk (treatment group) and low-risk (control group) countries graphically. Figure 3 shows that before the pandemic outbreak in March 2020, the export value time trends of the two groups were highly parallel, supporting our DD

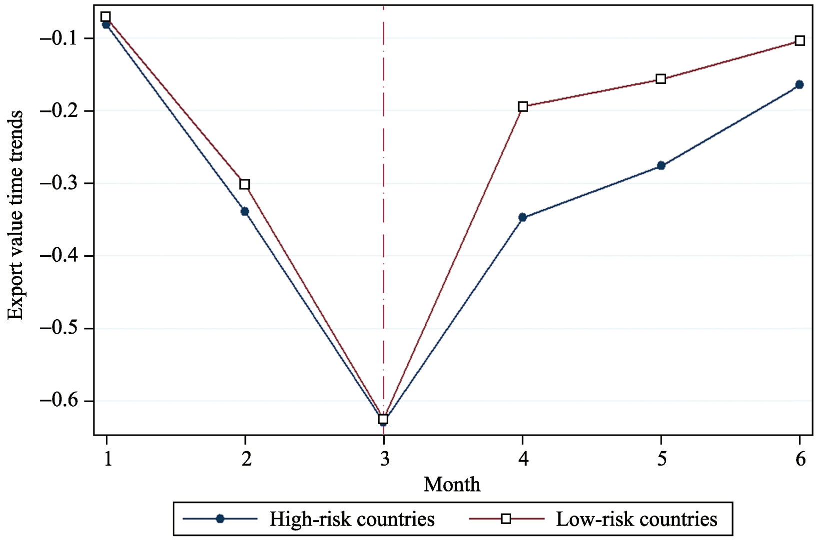

Figure 3 Product Exports by Pandemic Risk

Note: This figure reports the evolution of product exports for countries that are above or below the median pandemic risk. The vertical axis is the coefficients of the month dummies from the regressions, with controls for the bilateral tariff, country, and product fixed effects. The horizontal axis represents the months, which cover December 2019 to May 2020. The reference line (the vertical dot-and-dash line) corresponds to February 2020. The global pandemic began in March 2020.

assumption However, after the cutoff point, the export values of the two group start to diverge. We hypothesize that the gap between the two groups roughly results from the pandemic and its related lockdown policies, and we investigate the exact effects using the DD regression.

Table 1 reports the baseline results of the DD estimation for equation (1). The control variables are the bilateral tariff, exchange rate, and annual growth rate of IPI. Columns 1 and 2 control the month and country-product fixed effects, where the dependent variables are export value and price (natural logarithm), respectively. The coefficient on the interaction term is negative for export value and positive for export price, both of which are significant at the 1% level. These results indicate that the value of China's exports declined significantly after the onset of the pandemic. In contrast, the price of China's exports increased more in high-risk countries than in low-risk countries. There are three possible interpretations for the price rise in high-risk countries. First, the pandemic led to an increase in the cost of exporting due to the lockdown policies, as high-risk countries suffered more than low-risk countries. Second, higher prices in high-risk countries could be due to the higher market power of Chinese exporters compared to their competitors who suffered more from the pandemic. This interpretation is also consistent with the conclusion in Section 6.3, which provides evidence that China's exporters had higher market power after the pandemic based on the heterogeneous analysis of the import elasticity of substitution. Third, the higher prices of high-risk countries could be due to changes in the export product mix (total number of products exported to each country). Since the pandemic raised logistics costs, it would be rational for both exporters and importers to maximize the value of each shipment and favor higher-priced varieties over lower-priced ones. This would lead to a higher average price of exports. Therefore, we examine the impact of the pandemic risk on the export product mix. The results in Table A6 show that the change in the export product mix is insignificant.

We can attribute the increase in the price and decrease in the value to the leftward shift of the supply curve after the onset of the pandemic, reflecting the greater impact of the pandemic on the supply side due to the lockdowns and stringent cross-border policies. Taking Table 1 as our preferred specification, the estimate of –0.088 in column 1 indicates that the decrease in the value of exports was 8.8 percentage points higher in high-risk countries than in low-risk countries.

The estimate of 0.015 in column 2 indicates that the increase in the price of exports was 1.5 percentage points higher in high-risk countries.

Table 1 Baseline Results: Effect of the Pandemic on China's Exports

Variable of interest	(1) Export value (log)	(2) Price (log)
Risk×*Post*	–0.088***	0.015***
	(0.009)	(0.005)
Tariff	0.022***	–0.001
	(0.002)	(0.001)
IPI	0.006***	0.001***
	(0.000)	(0.000)
Exchange rate	–0.001***	0.000***
	(0.000)	(0.000)
Month fixed effect (FE)	Yes	Yes
Country×Product FE	Yes	Yes
Observations	1,267,934	1,267,934

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. Tariff is the bilateral import tariff at the country-product-monthly level for the United States, and the country-product level for the other partners. IPI and exchange rate are the annual growth rate of the industrial production index and bilateral exchange rate at the country and month level, respectively. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

5.2 Robustness Checks

In this subsection, we conduct several tests to ensure the robustness of our baseline results.

Alternative measures of pandemic risk. In the baseline model, we measure risk using a binary variable. To check for robustness, we use two alternative measures of risk. First, without weighting by population, we construct a dummy using the median of the number of cumulative confirmed cases as the cutoff. The estimation results in Table 2, columns 1 and 2 are consistent with our baseline estimates in both direction and significance level. Second, we use a continuous measure for pandemic risk defined as the cumulative number of confirmed cases divided by total population. The results in Table 2, columns 3 and 4, show that the pandemic still has a negative and significant effect on the value of exports, while the effect on the price of exports becomes insignificant, although it is still positive. Moreover, to ensure the robustness of our categorization of high- and low-risk countries by the median country risk (cumulative confirmed cases divided by total population), we also use the mean as another basis for grouping. The results in Table A7 indicate that the conclusions remain unchanged.

Table 2 Robustness Check: Alternative Pandemic Risk Measures

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Risk×*Post*	–0.151***	0.034***		
	(0.009)	(0.005)		
Risk (continuous) ×*Post*			–25.899***	1.794
			(2.188)	(1.329)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country×Product FE	Yes	Yes	Yes	Yes
Observations	1,267,934	1,267,934	1,267,934	1,267,934

Note: Robust standard errors clustered at the product level are in parenthesis. Pandemic risk in columns 1 and 2 is a binary variable equal to 1 for countries that have cumulative confirmed cases above the median and 0 otherwise. Pandemic risk in columns 3 and 4 is the cumulative confirmed cases divided by total population. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Removing the US from the sample. Our sample covers January 2019 to May 2020, during which the China–US trade friction had a significant impact on bilateral trade. Relative to January 2018, U.S. import tariffs and restrictions on Chinese exports increased significantly in 2019 and beyond. Despite our control using time-varying U.S. import tariffs on Chinese exports, non-tariff trade barriers between China and the US has still existed since 2018. For instance, some U.S. firms were forbidden to export certain products to Chinese firms, such as Zhongxing Telecommunication Equipment Corporation and Huawei Company.

In addition, the U.S. government imposed restrictions on investment from Chinese firms and encouraged U.S. firms to withdraw from China. All these polices created barriers to Chinese exporters and further damaged bilateral trade between the two countries (Amiti et al., 2020; Auray et al., 2020). Thus, this situation may contaminate our results by affecting Chinese exports to the US, particularly since the US had the most severe pandemic situation. To address this concern, we drop the US from our sample. The estimation results in Table 3 indicate that the interaction term of interest is still positive for export value and negative for price, and both are statistically significant at the 1% level.

Table 3 Robustness Check: Drop the US from the Sample

Variable of interest	(1) Export value (log)	(2) Price (log)
Risk×*Post*	–0.087***	0.018***
	(0.009)	(0.005)
Baseline controls	Yes	Yes
Month FE	Yes	Yes
Country×Product FE	Yes	Yes
Observations	1,207,553	1,207,553

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Subsample test. Considering the relatively short period of our sample (only 17 months), our finding that high-risk countries experienced a greater decline in exports than low-risk countries may also be due to factors unique to the first five months of each year. To eliminate this concern, we conduct a subsample test by selecting January to May 2020 and the corresponding period in 2019. Similar to the previous tables, columns 1 and 2 in Table 4 report the results for export value and export price with month and country-product fixed effects. Column 1 shows that the value of China's exports to high-risk countries declined by 9.6 percentage points more compared with that of exports to low-risk countries after the onset of the pandemic. The changes in the value of exports correspond with the baseline results and are significant at the 1% level. The results for the price of exports are also consistent with the baseline results, but the statistical significance decreases to the 10% level.

Table 4 Robust Check: Subsamples, 2019-01–2019-05 and 2020-01–2020-05

Variable of interest	(1) Export value (log)	(2) Price (log)
Risk×*Post*	–0.096***	0.010*
	(0.010)	(0.006)
Baseline controls	Yes	Yes
Month FE	Yes	Yes
Country×Product FE	Yes	Yes
Observations	784,864	784,864

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Difference between developed and developing countries. Table 5 reports the results for these two groups of countries. We find that the pandemic had significant negative effects on the value of China's exports to both groups of countries. The pandemic's effect on the price of China's exports to developed countries is insignificant, while it is highly significant in developing countries. These findings imply that it is more difficult for developed countries to accept the higher prices caused by the pandemic. We also conduct a robustness check with a continuous measure of pandemic risk. The results in Table A1 in the appendix are consistent with the baseline results, with the effect of the pandemic on the value of exports to developed countries being no longer significant.

Our results may differ for developed versus developing countries, perhaps for three reasons. First, the patterns of spread of the pandemic differed between developed and developing countries. Until the end of May 2020, most developed countries experienced a gradual reduction in new confirmed cases per day (the pandemic lasted two or three months on average). The situation in developing countries deteriorated steadily, with persistent growth of new confirmed cases, and there has been no sign of decline in new confirmed cases in these countries. Second, developed and developing countries have different abilities to deal with public health emergencies due to differences in medical conditions and government capacities. Third, the trade patterns also vary between these two groups of countries. Helpman and Krugman (1985) indicate that the scale of intra-industry trade depends on the relative factor endowment and the size of the economy. Although China's trade sector is upgrading, intra-industry trade is still scarce between China and developed countries, and inter-industry trade dominates. In contrast, the opposite is true between China and developing countries.

Table 5 Robustness Check: Developed Countries and Developing Countries Subsamples

Variable of interest	Developed countries		Developing countries	
	(1)	(2)	(3)	(4)
	Export value (log)	Price (log)	Export value (log)	Price (log)
Risk×*Post*	–0.060***	0.008	–0.105***	0.018***
	(0.020)	(0.012)	(0.011)	(0.007)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country×Product FE	Yes	Yes	Yes	Yes
Observations	488,523	488,523	779,411	779,411

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

6 Heterogeneity Analysis

A heterogeneity analysis will contribute to our understanding of how various industries or products responded to the pandemic differently. We use a DDD model to investigate the heterogeneous effects on different industries and products. Specifically, we focus on the position of China's industries in the GVC, labor intensity, contract intensity, and the elasticity of substitution of different export products.

6.1 Position in the GVC

The GVC is increasingly important for understanding firms' exporting behaviors (Hoekman, 2015). In this subsection, we explore the roles of the position in the

GVC in determining the effects of the pandemic. We use Koopman et al.'s (2010) GVC position index to measure China's position and importance in the GVC. The index identifies the GVC position (upstream or downstream) by the relative ratio of the components [indirect value (IV) added and foreign value (FV) added] of the export value added. A higher proportion of IV in exports means that the country tends to export more raw materials or intermediate products, referred to as forward participation in the GVC. A higher proportion of FV in exports means that the country tends to export more final goods, referred to as backward participation. The pandemic likely affected the exports of upstream goods more than those of downstream goods because the pandemic affected more countries that demanded a large share of upstream goods.

Table 6 reports the results of DDD estimation of the GVC position. Columns 1 and 2 show that the coefficients on our variable of interest, the triple interaction, are –0.220 and 0.061 for export value and price, respectively, and both are significant at the 1% level (baseline specification). This result implies that forward participation (upstream) in a GVC is more vulnerable and suffered more from pandemic-induced trade barriers. The results are consistent with the assumption that the pandemic had a greater effect on the exports of upstream goods than those of downstream goods because more high-risk countries were involved in the demand for upstream goods. In columns 3 and 4, we use a specification that controls for month fixed effects, country fixed effects, and product fixed effects. Moreover, following Koopman et al. (2010), the specification controls for the GVC position and participation indices of partners to summarize the importance of the global supply chain for all partners. The results in columns 3 and 4 indicate that this refined specification hardly affects our main results. We also carry out a robustness check using the continuous measure of pandemic risk, and the results in Table A2 remain unchanged, but with greater significance.

6.2 Labor and Contract Intensity

We measure industrial labor intensity by U.S. human capital intensity, which is a good instrumental variable for Chinese labor intensity in case of endogeneity (Che and Zhang, 2018). We investigate labor intensity because it is closely related to processing trade and reflects export competitiveness, as Dai et al.

Table 6 Heterogeneous Effects across Industries: The GVC Position (China)

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
GVC_position×Risk×Post	–0.220***	0.061***	–0.161***	0.088***
	(0.038)	(0.018)	(0.047)	(0.021)
Risk×Post	–0.275***	–0.003	0.401***	–0.119***
	(0.040)	(0.014)	(0.068)	(0.022)
GVC_position×Risk			–0.225***	0.002
			(0.044)	(0.017)
GVC_position×Post	–0.537***	0.141***	–0.396***	0.196***
	(0.080)	(0.038)	(0.097)	(0.043)
GVC_position (partner)			–0.080***	0.005
			(0.028)	(0.011)
GVC_participation (partner)			0.003**	0.003***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	Yes
Product FE	No	No	Yes	Yes
Country ×product FE	Yes	Yes	No	No
Observations	1,071,969	1,071,969	980,067	980,067

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

(2016) demonstrate. They show that processing exports in China account for 66% of total exports in labor intensive sectors but only 39% in capital intensive sectors. They further conclude that compared with non-processing exporters, processing exporters have inferior performance in productivity, wages, research and development, and skill intensity.

Table 7 reports the estimates related to labor intensity. In column 1, the estimates with month and country fixed effects show that exports with greater labor intensity suffered heavier losses due to the pandemic. Column 2 shows that the price of exports increased due to the high trade barriers induced by the pandemic. These results are consistent with those of existing studies. For instance, Bergin et al. (2011) find that industries dominated by processing trade are associated with higher volatility. In Table 7, columns 3 and 4 report results with

Table 7 Heterogeneous Effects across Industries: Labor Intensity

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Labor_intensity×Risk×Post	–1.082***	0.133	–0.744***	0.141
	(0.184)	(0.089)	(0.218)	(0.105)
Risk×Post	0.846***	–0.099	0.577***	–0.106
	(0.159)	(0.079)	(0.189)	(0.093)
Labor_intensity×Risk			2.084***	0.111
			(0.335)	(0.112)
Labor_intensity×Post	–2.320***	0.073	–1.923***	–0.078
	(0.191)	(0.077)	(0.204)	(0.086)
GVC_position (partner)			–0.056**	0.010
			(0.027)	(0.011)
GVC_participation (partner)			0.004***	0.003***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	No	No	No	No
Product FE	No	No	Yes	Yes
Country×Product FE	Yes	Yes	Yes	Yes
Observations	1,058,651	1,058,651	967,577	967,577

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Labor intensity* is the percentage of workers without a 4-year college education or above in an industry, as in Ciccone and Papaioannou (2009). The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

alternative fixed effects or more controls, and the conclusions remain unchanged, except that the impact on the price of exports is no longer significant. A robustness check with continuous pandemic risk shows that the results have the same direction and significance (Table A3).

In addition to labor intensity, we employ contract intensity to identify processing exports. As Feenstra et al. (2013) indicate, processing trade in China is usually contract intensive in the sense that exporters export goods with the characteristics specified by the buyer and receive payment accordingly. We adopt Nunn's (2007) measure of industrial contract intensity, which is the proportion of intermediate inputs that require relationship-specific investments. Importers rather than the market mainly determine the exports with greater contract intensity. Table 8 reports results that are consistent with Table 7, but with higher levels of significance. With the month and country fixed effects (columns 1 and 2), the value of exports suffers a larger decline and the price of exports shows a greater increase due to the sharp rise in the cost of trade. The results in columns 3 and 4 are highly consistent with those in the first two columns. The estimates related to labor intensity and contract intensity support the conclusion that processing exports suffered much more than non-processing exports from the pandemic. A robustness check with continuous pandemic risk supports this conclusion (Table A4).

Table 8 Heterogeneous Effects across Industries: Contract Intensity

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Contract_intensity×Risk×Post	–0.170***	0.112***	–0.216***	0.213***
	(0.048)	(0.027)	(0.058)	(0.032)
Risk×Post	–0.005	–0.043***	0.044	–0.100***
	(0.027)	(0.014)	(0.033)	(0.017)
Contact-intensity×Risk			1.170***	–0.463***
			(0.086)	(0.040)
Contact-intensity×Post	–0.377***	0.025	–0.188***	–0.056**
	(0.048)	(0.023)	(0.051)	(0.027)
GVC_position (partner)			–0.074**	–0.000
			(0.029)	(0.011)
GVC_participation (partner)			0.005***	0.003***
			(0.001)	(0.001)

(*To be continued*)

(*Continued*)

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	No	No	Yes	Yes
Product FE	No	No	Yes	Yes
Country*Product FE	Yes	Yes	Yes	Yes
Observations	1,058,651	1,058,651	967,577	967,577

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Contract_intensity* is constructed and used following Nunn (2007); that is, it is the proportion of intermediate inputs that require relationship-specific investments. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

6.3 Elasticity of Substitution

The differing levels of pandemic risk and corresponding policy responses across countries disrupted global supply chains (Baldwin and Mauro, 2020), which may adjust to the new trade environment in the post-pandemic era. The elasticity of substitution is crucial for determining export stability and market power (Broda et al., 2008), and may thus play an important role in determining the changes in exports under the pandemic. Pandemic-induced trade barriers caused a contraction in global supply (outside China), which provides opportunities for Chinese exporters with higher import elasticity of substitution (for specific products from different countries) to grow their market shares or raise the prices for specific products. For products with lower import elasticity of substitution, it is difficult to substitute the same products from other countries.

Therefore, Chinese products with high elasticity of substitution may suffer less, or even perform better in terms of market share (or export price) in a specific country due to the contraction in the supply by their competitors, who are suffering from the spread of the pandemic. We investigate whether the impact of the pandemic differs for products with various elasticity of substitution. We use the elasticity of substitution at the HS 6-digit product level estimated from U.S. import data to capture the substitution between China's exports and exports from other sources, considering that there are more varieties of U.S. imports compared with other countries over the past decades.

The first two columns in Table 9 report the estimates with time and country fixed effects. Higher elasticity contributes to higher prices of export at the 1% level, while the value of exports also increases but not significantly. These findings are in line with our expectation. High elasticity of substitution helped to stabilize China's exports during the pandemic, especially because the price of exports (highly significant) and the value of exports increased with the elasticity of substitution. These findings imply that the impact of the pandemic is heterogeneous according to the product's elasticity of substitution, and high elasticity of substitution helped to lower the export risk caused by the pandemic.

Table 9 Heterogeneous Effects across Products: Import Elasticity of Substitution

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Elasticity×Risk×Post	0.0001	0.0003***	0.0001	0.0007***
	(0.000)	(0.000)	(0.000)	(0.000)
Risk×Post	–0.091***	0.002	–0.075***	–0.011
	(0.013)	(0.006)	(0.015)	(0.007)
Elasticity×Risk			0.000	–0.001***
			(0.000)	(0.000)
Elasticity×Post	0.000	0.000	–0.000	–0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Market share			12.281***	0.037
			(0.201)	(0.070)
GVC_position (partner)			–0.089***	0.007
			(0.024)	(0.011)
GVC_participation (partner)			0.001	0.003***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes

(*To be continued*)

(*Continued*)

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Country FE	No	No	Yes	Yes
Product FE	No	No	Yes	Yes
Country×Product FE	Yes	Yes	Yes	Yes
Observations	1,148,989	1,148,989	970,151	970,151

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Elasticity* is the elasticity of substitution of U.S. imports estimated using the GMM estimation of Broda et al. (2008). Market share is the value of China's exports of a specific good to a specific country divided by the total value of China's exports of that specific good at the country-product level, and calculated using Chinese Customs data for 2017–2019. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

To eliminate the influence of the importance of different trading partners, we further control for market share (measured as the value of China's exports of a specific good to a specific country divided by the total value of China's exports of that specific good at the country-product level calculated using Chinese Customs data for 2017–2019). In Table 9, columns 3 and 4 report the results with alternative fixed effects (e.g., product FE, country FE, and month FE) and more controls. The findings remain consistent with those in the first two columns in both direction and significance. A robustness check with continuous pandemic risk suggests the same conclusion (Table A5).

7 Conclusion

The COVID-19 pandemic caused monumental negative economic consequences globally. In this study, we investigated the impact of the pandemic on China's exports. Using a DD framework and monthly exports data at the product level, we find that the COVID-19 pandemic caused a decrease of 8.8 percentage points in the value of China's exports to countries with high pandemic risk (compared with low-risk countries). Furthermore, the price of China's exports increased by 0.015 percentage points in the high-risk countries since the onset of the pandemic (compared with low-risk countries). Our conclusions are robust and statistically significant under various robustness checks, including alternative measures of pandemic risk, removing the US from the sample, applying subsample analyses, and distinguishing between developed and developing countries.

To further clarify how the COVID-19 pandemic affected China's exports, we employed a DDD specification to investigate how our main results depend on industry and product characteristics. We find that compared with backward participation, industries and products with forward participation (upstream) in GVCs are more vulnerable and suffered more from the pandemic. Industries with high labor and contract intensity had greater pandemic-induced export losses and price increases, which implies that processing exports suffered more from the pandemic. Lastly, our results show that exports with high import elasticity of substitution performed better and helped to stabilize China's exports.

A limitation of our study is that due to the relatively short sample period, we can interpret our results only in the short run. That is, the negative effects of the pandemic are driven by the lockdown policies and thus disruptions of global supply chains over a short period. However, the consensus seems to be that the pandemic will last much longer, especially considering the current situation in the most important economy, the US. The pandemic will likely have far-reaching impacts on the global economy (Guerrieri et al., 2020). Therefore, further study of its economic effects is worthwhile, especially research into the medium and long run.

Acknowledgements Yi Che gratefully acknowledges support from the National Natural Science Foundation of China (NSFC, Grant No. 72073095 and 71703099) and Shanghai International Institute of Finance and Economics. Yan Zhang gratefully acknowledges support from the Young Scientists Fund of the National Natural Science Foundation of China (NSFC, Grant No. 71703085).

References

Acemoglu D, Makhdoumi A, Malekian A, Ozdaglar A (2020). Testing, voluntary social distancing and the spread of an infection. NBER Working Paper, No. 27483

Alfaro L, Chari A, Greenland A, Schot P K (2020). Aggregate and firm-level stock returns during pandemics, in real time. NBER Working Paper, No. 26950

Amiti M, Kong S H, Weinstein D (2020). The effect of the U.S.-China trade war on U.S. investment. NBER Working Paper, No. 27114

Auray S, Devereux M B, Eyquem A (2020). Trade wars, currency wars. NBER Working Paper, No. 27460

Autor D, Cho D, Crane L D, Goldar M, Lutz D, Montes J, Peterman W B, Ratner D, Villar D, Yildirmaz A (2020). An evaluation of the paycheck protection program using administrative payroll microdata. http://economics.mit.edu/ files/20094, visited on July 27, 2020

Baldwin R, Mauro B W (2020). Economics in the Time of COVID-19, 1st ed. London, UK: CEPR Press

Barua S (2020). COVID-19 pandemic and world trade: Some analytical notes. MPRA Papers, No. 99761. Visited on July 28, 2020, https://mpra.ub.uni-muenchen.de/99761/1/MPRA_paper_99761.pdf

Bergin P R, Feenstra R C, Hanson G H (2011). Volatility due to offshoring: Theory and evidence. Journal of International Economics, 85(2): 163–173 doi:10.1016/j.jinteco.2011.08.001

Broda C, Limao N, Weinstein D (2008). Optimal tariffs and market power: The evidence. American Economic Review, 98(5): 2032–2065 doi:10.1257/aer.98.5.2032

Che Y, Zhang L (2018). Human capital, technology adoption, and firm performance: Impacts of China's higher education expansion in the late 1990s. The Economic Journal, 128(614): 2282–2320 doi:10.1111/ecoj.12524

Chen Z, Voia M C (2018). Short-term and long-term margins of international trade: Evidence from the Canada-Chile Free Trade Agreement. Frontiers of Economics in China, 13(1): 93–115 doi:10.3868/s060-007-018-0008-2

Ciccone A, Papaioannou E (2009). Human capital, the structure of production, and growth. Review of Economics and Statistics, 91(1): 66–82 doi:10.1162/rest.91.1.66

Dai M, Maitra M, Yu M (2016). Unexceptional exporter performance in China? The role of processing trade. Journal of Development Economics, 121: 177–189 doi:10.1016/j.jdeveco.2016.03.007

Feenstra R C (1994). New product varieties and the measurement of international prices. American Economic Review, 84(1): 157–177

Feenstra R C, Hong C, Ma H, Spencer B J (2013). Contractual versus non-contractual trade: The role of institutions in China. Journal of Economic Behavior & Organization, 94: 281–294 doi:10.1016/j.jebo.2013.08.009

Guerrieri V, Lorenzoni G, Straub L, Werning I (2020). Macroeconomic implications of COVID-19: Can negative supply shocks cause demand shortages? NBER Working Paper, No. 26918

Hassani K, Dost S (2020). Impact of COVID 19 on international trade and China's trade. Turkish Economic Review, 7(2): 103–110 doi:10.1453/ter.v7i2.2079

Head K, Mayer T (2014). Gravity equations: Workhorse, toolkit, and cookbook. Handbook of International Economics, 4: 131–195

Helpman E, Krugman P R (1985). Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy. Cambridge, MA: The MIT Press

Hoekman B (2015). The Global Trade Slowdown: A New Normal. VoxEU eBook, Centre for Economic Policy Research. https://voxeu.org/sites/default/files/file/Global Trade Slowdown_nocover.pdf, visited on July 29, 2020

Koopman R, Powers W, Wang Z, Wei S J (2010). Give credit where credit is due: Tracing value added in global production chains. NBER Working Paper, No. 16426

Maliszewska M, Mattoo A, Mensbrugghe D (2020). The potential impact of COVID-19 on GDP and trade: A preliminary assessment. Policy Research Working Paper, No. 9211, World Bank. http://documents.worldbank.org/curated/en/295991586526445673/pdf/The-Potential-Impact-of-COVID-19-on-GDP-and-Trade-A-Preliminary-Assessment.pdf, visited on July 29, 2020

Moser C A, Yared P (2020). Pandemic lockdown: The role of government commitment. NBER Working Paper, No. 27062

Nunn N (2007). Relationship-specificity, incomplete contracts, and the pattern of trade. Quarterly Journal of Economics, 122(2): 569–600 doi:10.1162/qjec.122.2.569

Appendix

Table A1 Robustness Check: Continuous Pandemic Risk, Developed Countries and Developing Countries

Variable of interest	Developed countries		Developing countries	
	(1)	(2)	(3)	(4)
	Export value (log)	Price (log)	Export value (log)	Price (log)
Risk×*Post*	–4.857	–11.208***	–31.283***	5.102***
	(5.304)	(3.404)	(2.380)	(1.401)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country×Product FE	Yes	Yes	Yes	Yes
Observations	488,523	488,523	779,411	779,411

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is the cumulative confirmed cases divided by total population. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A2 Heterogeneous Effects across Industries: Continuous Pandemic Risk, GVC Position (CHN)

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
GVC_position×Risk×Post	–58.606***	14.563***	–40.623***	21.314***
	(8.713)	(3.530)	(12.585)	(5.536)
Risk×Post	–146.086***	31.769***	–101.649***	42.924***
	(18.157)	(7.301)	(25.932)	(11.565)
GVC_position×Risk			121.723***	–40.964***
			(18.927)	(6.040)
GVC_position×Post	–0.264***	–0.013***	–0.223***	0.004
	(0.038)	(0.003)	(0.043)	(0.017)
GVC_position (partner)			–0.073***	0.001
			(0.028)	(0.011)
GVC_participation (partner)			0.003**	0.003***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Product FE	No	No	Yes	Yes
Country×Product FE	No	No	Yes	Yes
Observations	980,067	980,067	1,071,969	1,071,969

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is the cumulative confirmed cases divided by total population. *Post* is a dummy equal to 1 for months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A3 Heterogeneous Effects across Industries: Continuous Pandemic Risk, Labor Intensity

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Labor_intensity×*Risk*×*Post*	–303.718***	–9.24	–401.717***	–16.637
	(42.384)	(23.138)	(54.093)	(27.213)
Risk×*Post*	236.120***	9.946	327.442***	13.290
	(36.760)	(20.491)	(46.808)	(23.966)
Labor_intensity×*Risk*			511.687***	–31.971
			(64.990)	(30.149)
Labor_intensity×Post	–2.235***	0.172**	–1.469***	0.052
	(0.181)	(0.078)	(0.193)	(0.085)
GVC_position (partner)			–0.054**	0.005
			(0.023)	(0.011)
GVC_participation (partner)			0.002	0.003***
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Product FE	No	No	Yes	Yes
Country×Product FE	No	No	Yes	Yes
Observations	1,058,651	1,058,651	967,577	967,577

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is the cumulative confirmed cases divided by total population. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Labor_intensity* is the percentage of workers without a 4-year college education or above in an industry calculated using U.S. data for 1980 (Ciccone and Papaioannou, 2009). The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A4 Heterogeneous Effects across Industries: Continuous Pandemic Risk, Contract Intensity

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Contract_intensity×Risk×Post	–50.067***	24.189***	–87.375***	49.031***
	(11.299)	(6.889)	(16.891)	(8.467)
Risk×Post	–1.649	–11.035***	26.741***	–27.022***
	(6.424)	(3.504)	(8.826)	(4.268)
Contract_intensity×Risk			278.902***	–130.581***
			(23.074)	(11.404)
Contract_intensity×Post	–0.356***	0.033	–0.093*	–0.051*
	(0.046)	(0.024)	(0.052)	(0.028)
GVC_position (partner)			–0.074***	–0.002
			(0.029)	(0.011)
GVC_participation (partner)			0.005***	0.002***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Product FE	No	No	Yes	Yes
Country×Product FE	No	No	Yes	Yes
Observations	1,058,651	1,058,651	967,577	967,577

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is the cumulative confirmed cases divided by total population. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Contract_intensity* is constructed and used following Nunn (2007); that is, it is the proportion of intermediate inputs that require relationship-specific investments. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A5 Heterogeneous Effects across Products: Continuous Pandemic Risk, Import Elasticity of Substitution

Variable of interest	(1) Export value (log)	(2) Price (log)	(3) Export value (log)	(4) Price (log)
Elasticity×*Risk*×*Post*	0.020	0.067**	–0.068	0.141***
	(0.041)	(0.028)	(0.054)	(0.036)
Risk×*Post*	–26.030***	–0.673	–16.051***	–6.390***
	(2.959)	(1.603)	(3.640)	(1.938)
Elasticity×*Risk*			–0.137**	–0.406***
			(0.063)	(0.047)
Elasticity×*Post*	0.000	0.000	0.000	–0.000***
	(0.000)	(0.000)	(0.063)	(0.000)
Market share			12.296***	0.047
			(0.201)	(0.070)
GVC_position (partner)			–0.090***	0.008
			(0.024)	(0.011)
GVC_participation (partner)			0.000	0.003***
			(0.001)	(0.001)
Baseline controls	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Product FE	No	No	Yes	Yes
Country×Product FE	No	No	Yes	Yes
Observations	1,148,989	1,148,989	970,151	970,151

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is the cumulative confirmed cases divided by total population. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. *GVC_position* and participation indices are calculated at the country-sector level following Koopman et al. (2010) using the 2015 trade value added data from the TiVA database. *Elasticity* is the elasticity of substitution between different countries for each product estimated using the GMM estimation of Broda et al. (2008). Market share is the value of China's exports of a specific good to a specific country divided by the total value of China's exports of that specific good at the country-product level, calculated using Chinese Customs data for 2017–2019. The other variables are defined as in Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A6 The Effect of Pandemic Risk on the Export Product Mix

Variable of interest	Total number of products
Risk×*Post*	–22.137
	(31.353)
IPI	0.261
	(1.288)
Exchange rate	–0.708***
	(0.162)
Country FE	Yes
Time FE	Yes
Observations	617

Note: The dependent variable is total number of products exported at the country and month level. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the median and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. IPI and exchange rate are the annual growth rate of industrial production index and bilateral exchange rate at the country and month level, respectively. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A7 Results Grouped by the Mean Country Risk

	(1)	(2)
Variable of interest	Export value (log)	Price (log)
Risk×*Post*	–0.085***	0.018***
	(0.009)	(0.005)
Tariff	0.021***	–0.001
	(0.002)	(0.001)
IPI	0.327***	0.150***
	(0.033)	(0.022)
Exchange rate	–0.001***	0.000***
	(0.000)	(0.000)
Month FE	Yes	Yes
Country×Product FE	Yes	Yes
Observations	1,267,934	1,267,934

Note: Robust standard errors clustered at the product level are in parenthesis. *Risk* is a binary variable equal to 1 if the cumulative confirmed cases divided by total population is above the mean and 0 otherwise. *Post* is a dummy equal to 1 for the months after March 2020 and 0 otherwise. Tariff is the bilateral import tariff at the country-product-monthly level for the US and at the country-product level for the other partners. IPI and exchange rate are the annual growth rate of industrial production index and bilateral exchange rate at the country and month level, respectively. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table A8 List of Medical Supplies

HS code	Commodity
392620	Plastics; articles of apparel and clothing accessories (including gloves, mittens and mitts)
392690	Plastics; other articles n.e.c. in Chapter 39
401511	Rubber; vulcanised (other than hard rubber), surgical gloves
401519	Rubber; vulcanised (other than hard rubber), gloves, mittens and mitts other than surgical gloves
401699	Rubber; vulcanised (other than hard rubber), articles n.e.c. in heading no. 4016, of non-cellular rubber
621010	Garments; of felt or non-wovens (not knitted or crocheted)
630790	Textiles; made up articles (including dress patterns), n.e.c. in chapter 63, n.e.c. in heading no. 6307
650500	Hats and other headgear; knitted or crocheted, or made up from lace, felt or other textile fabric, in the piece (but not in strips), whether or not lined or trimmed; hair-nets of any material, whether or not lined or trimmed
900490	Spectacles, goggles and the like; (other than sunglasses) corrective, protective or other
300590	Wadding, gauze, bandages and similar articles; (excluding adhesive dressings), impregnated or coated with pharmaceutical substances, packaged for retail sale
380894	Disinfectants; other than containing goods specified in Subheading Note 1 in this Chapter; put up in forms or packings for retail sale or as preparations or articles
901819	Medical, surgical instruments and appliances; electro-diagnostic apparatus (including apparatus for functional exploratory examination or for checking physiological parameters), n.e.c. in item no. 9018.1
901920	Therapeutic respiration apparatus; ozone, oxygen, aerosol therapy apparatus; artificial respiration or other therapeutic respiration apparatus
902519	Thermometers and pyrometers; (other than liquid filled, for direct reading), not combined with other instruments

Note: The list of medical supplies is from the Announcement No. 53 of 2020 by China's General Administration of Customs.