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COVID-19 and trade: Simulated asymmetric loss

Chunding Li, Xin Lin*

College of Economics and Management, China Agricultural University, Beijing, China

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A B S T R A C T

This paper uses 2018 data as a benchmark to build a numerical 26-country global general equilibrium model with trade cost and an endogenous trade imbalance structure. We assume that COVID-19 will increase the trade cost between countries and decrease labor supply in production. We use China’s trade data from January to April in 2020 to calibrate the influence level parameters and then simulate the trade effects of COVID-19 in China, the EU, the US, and the world. Our simulation results find that all countries' trade and exports will be significantly hurt by the pandemic. Due to the trade diversion effect and the price growth effect, some countries will see an increase in import trade. Comparatively, the pandemic has the most negative impact on global trade, followed by the EU, the US, and China. As the pandemic deepens, the negative impact on trade will increase. The worldwide pandemic has the most significant impact on US trade, with an effect about 1.5 times that of the average world effect.

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1. Introduction

Since the COVID-19 outbreak evolved into a global pandemic, the various countries have seen heavy impacts on their trade systems. While invading the human body, the coronavirus also "infected" the global supply chain connecting producers and consumers, due to the world is closely integrated through intermediate and final goods. The spread of the COVID-19 pandemic has triggered countries to take measures such as enacting restrictions on transport and labor mobility, even mandating workplace closures, which acted as shocks to the economy. Moreover, from both the supply side and the demand side, the crisis has affected the trade of goods and services. The uncertainty faced by enterprises engaged in import or export trade and international investment has increased significantly.

The disaster has a certain similarity to the SARS outbreak in 2003, which also rapidly developed into the global epidemic due to its high infectivity. Lee and Mckibbin (2004) provide an assessment of the global economic impacts of SARS, with empirical estimates based on a global model called the G-Cubed model. Their results reveal that the economic impact of SARS depended on the adjustment of expectations about the disease, reflected in integrated real and financial markets. Studies including Hai et al. (2004), Hanna and Huang (2004), and Siu and Wong (2004) also analyze the economic impacts of SARS. In addition, some scholars estimate the impact of other diseases such as H1N1 and avian influenza on macroeconomies (Anaeto and Chioma, 2007; George et al., 2010). However, compared with the situation in 2003, the environment of the world

* Corresponding author at: 17 Qinghua East Road, Haidian, Beijing, China.
E-mail addresses: lichd@cau.edu.cn (C. Li), linxin@cau.edu.cn (X. Lin).

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economy and the scale of international trade has changed greatly, and the impact of COVID-19 on the global industrial chain and supply chain is much higher than during the SARS period. Although we can learn from relevant experience, we cannot simply use the situation during SARS to analyze current problems, otherwise we will most likely make erroneous predictions. With the escalation of the pandemic, research on its impact on the economy has become the focus of academic researchers (Eichenbaum et al., 2020; Baker et al., 2020; Guerrieri et al., 2020; Olivier et al., 2020; Bonadio et al., 2020; Park et al., 2020).

Nevertheless, few studies include a quantitative analysis of the pandemic’s effect on trade. Our paper makes three distinct contributions to the related literature. Firstly, in order to analyze the negative impacts of the pandemic on trade more comprehensively, we take into account non-tariff as well as tariff barriers, and use advanced methods to consider endogenous trade imbalances in the model. Secondly, we measure the true shock of the pandemic based on the number of confirmed cases in each country, and consider the disruption of trade to improve the accuracy and reliability of the estimation results. Thirdly, we find that the impact on trade is asymmetric, and the main factor is related to the competitiveness of each country. It’s necessary to note that even in times of global crisis, the economic power that has been built up over time is important.

In this paper, considering that the trade impacts of the COVID-19 crisis on the major countries are varied, we build a numerical general equilibrium (GE) model to simulate the trade effects of different epidemic scenarios in China, the EU, the US, and the world. We quantitatively analyze the trade impacts of COVID-induced uncertainties. The results reveal that the spread of the pandemic in different periods has asymmetrical effects on trade among countries. The main reason is that the different stages of the pandemic’s progress in various countries leads to the misalignment of the supply and consumption sides of global trade.

The rest of this paper is organized as follows. Section 2 describes the global development of COVID-19 and mechanisms of its impact on trade. Section 3 introduces the general equilibrium model, data, and parameter calibration. Section 4 reports our simulation results and sensitivity analysis. We close with conclusions and remarks in the last section.

2. Global development of COVID-19 and impacts on trade

2.1. Development of the COVID-19 pandemic

In December 2019, a series of pneumonia cases of unknown origin appeared in Wuhan, China. On 20 January 2020, the academic Nanshan Zhong confirmed that there was human-to-human transmission of this pneumonia. Subsequently, China immediately imposed restrictions and even placed Wuhan under lockdown. In the meantime, the pneumonia also appeared in other countries. On 30 January, the World Health Organization (WHO) announced the pandemic as a “Public Health Emergency of International Concern” (PHEIC), and on 11 February, the WHO officially named the pneumonia caused by coronavirus “COVID-19.” The COVID-19 pandemic spread around the world on account of its long incubation period and the cross-border movement of people. Countries responded differently to this crisis.

Since mid-March, China’s situation has been under control. Japan, South Korea, Singapore, and other Asian countries also implemented measures such as extensive isolation, self-protection, and centralized treatment at an earlier stage of the outbreak. These countries successfully controlled the epidemic in a relatively short period of time. But as the pandemic spread to the EU, Italy, Spain, Germany, and France became the pandemic epicenters. With the gradual easing of the pandemic in the EU, outbreaks in the US that were not effectively controlled made the US a new epicenter. The pandemic has also spread to South America, Africa, and Oceania. Due to insufficient medical resources and economic pressure, the pandemic situation is still severe in these regions. As the pandemic has rebounded after the blockade in some countries is lifted, the number of diagnosed cases still surge daily. Up to now, the number of confirmed cases of COVID-19 in the world has exceeded 100 million. What’s more worrying is that the coronavirus has mutated in some countries or regions.

2.2. Impact mechanisms of the pandemic on trade

The negative impact of the COVID-19 on economy is inevitable. It not only affects the normal development of production activities, but also increases the cost of economic activities and reduces the income of residents. The impact of COVID-19 on trade is also significant. There are three main channels of COVID-19’s impact on trade. The first channel is reduced supply and supply capacity. (I) Policies prohibiting the movement and gathering of people forces export enterprises to limit production and work, or even shut down. Orders cannot be delivered on time and contracts are breached. (II) When the supply of raw materials and intermediate inputs is insufficient, production cannot function normally. The sudden exogenous shocks inevitably interrupt the supply chain of processing trade enterprises. (III) Enterprises also face the dilemma of rising production costs, making it likely that they will lose their price competitiveness and their export markets. (IV) The inability of companies to recover funds and earnings in a timely fashion leads to rising financing costs and difficulties in the capital chain.

The second channel is a reduction in foreign demand. (I) In addition to food and pandemic prevention items, the demand for most overseas commodities has seen a downward trend, which increases the export pressure of enterprises. (II) If companies’ export supply and competitiveness continue to decline over a longer period, demand may be transferred to other countries and regions, resulting in changes in the global value chain. (III) The economic recession provoked by the pandemic has weakened the purchasing power of consumers, and the demand for import goods will also be reduced.
The third channel is to increase the cost of trade. (I) Trade-related logistics services and declaration procedures can be hindered, which will increase the time and costs of animal transport, storage, quarantine, and customs clearance. (II) Most countries have introduced immigration control measures to prevent coronavirus spread. Some countries may build new trade barriers on the grounds of the pandemic.

3. General equilibrium model, data, and parameter calibration

3.1. GE model

The theoretical model is based on the standard general equilibrium structure, which mainly includes three aspects: (I) Production side: Set the production function in the form of CES and assume that T factors are used to produce N products. The demand for factor input is determined according to the maximum output under the constraints of factor endowments. (II) Consumption side: Establish a two nested CES utility function form. Consumers choose between different products in the first nest and between products from different countries in the second nest. (III) Market clearing conditions: The market clearing conditions in the GE model should meet the four requirements: demand equilibrium, supply equilibrium, trade equilibrium, and zero profit under perfect competition. The overall structure of the general equilibrium equation is presented in Table A1 of the Appendix.

Furthermore, this article introduces two important elements. First, we simultaneously take into account tariff and non-tariff structure. Second, we use inside money to endogenously determine the trade imbalance. The expanded import strategy includes both the reduction of tariffs and non-tariff barriers such as trade facilitation, while most studies only retain the structure of non-tariff barriers. Tariff measures are usually reflected in the consumer price of imported products, so we define import tariff in country $i$ as $t_i$. The relationship between consumer price and producer price of trade goods $l$ imported by country $i$ from country $j$ is:

$$pc_{ij} = (1 + t_i)p_j^l$$

where $pc_{ij}$ is the consumer price of import country $i$, and $p_j^l$ is the producer price of export country $j$.

Note that the revenue from tariffs $R_i$ is simply:

$$R_i = \sum_l \sum_{i,j} p_{ij}X_{ij}t_i$$

where $x_{ij}$ is country $i$’s import demand for goods $l$ in country $j$.

Non-tariff barriers similarly affect the consumer prices of imported products, and we denote non-tariff barriers as $N_{ij}$. The relationship becomes:

$$pc_{ij} = (1 + t_i + N_{ij})p_j^l$$

Since non-tariff barriers include extra expenditures such as transportation, language, systems, and technical standards, etc., we define these costs as $NR_i$, the cost of non-tariff barriers:

$$NR_i = \sum_l \sum_{i,j} p_{ij}X_{ij}N_{ij}$$

After introducing tariff and non-tariff barriers, we denote country $i$’s consumer income as $I_i$, and we have

$$\sum_t w^t \overline{F}^t + R_i = I_i$$

Here, $\overline{F}^t$ is the endowment of factor $t$ in country $i$, and $w^t$ is price of factor $t$.

Non-traded goods should afford the cost of non-tariff barriers, and the relationship among output $Q_{iNT}^l$, production price $p_{iNT}^l$ and demand $X_{iNT}^l$ meets the condition:

$$Q_{iNT}^l = \frac{NR_i}{p_{iNT}^l} + X_{iNT}^l$$

We introduce trade imbalance structure into our model. Generally, there are three trade imbalance modeling approaches: (I) exogenous and fixed trade imbalance structure, which is based on the level of trade imbalance in the benchmark situation; (II) monetary endogenous structure, in which the level of trade imbalance is determined by the difference between consumption expenditure and constant money supply; and (III) endogenous trade imbalance of inside money, which is derived from the inside money formula in Patinkin (1971), Li and Whalley (2014), Whalley et al. (2011), apply this modeling method to the GE model structure, and the results of the numerical simulation find that the structure is stable and reliable, so this paper introduces the endogenous trade imbalance of endogenous currency.
The specific modeling approach is to set inside money, which is equal to a country’s trade imbalance. The positive value of the trade surplus and the negative value of the trade deficit represent the power to purchase future consumption with inside money, as well as the overdraft of future consumption with inside money issued and borrowed, respectively. The utility function contains inside money, which not only characterizes a country’s preference for trade surplus, but also optimizes under budget constraints to determine the trade imbalance endogenously. As the value of the utility function cannot be negative, it is necessary to set a suitable upbound number for nominal inside money so that the sum of the upbound number and trade imbalance for any country is larger than zero. In this way, the level of trade imbalance can be expressed in the utility function, and the problem of the negative value in the trade deficit can be resolved. All in all, the mechanism of introducing inside money affects the structure of consumption and production through consumer budget constraints, endogenously determining trade imbalances.

To explore the pandemic’s impacts on trade, we introduce two mechanisms in this paper. One is that the pandemic increases non-tariff barriers. Increased non-tariff barriers will reduce trade between countries. The second is that the pandemic decreases labor input in production, which reduces the production and goods supply.

3.2. Data and parameter calibration

We include 26 countries/regions in our numerical GE model: China, Brazil, India, Mexico, Russia, Malaysia, Indonesia, Thailand, Vietnam, the Philippines, the US, the EU, Japan, Canada, Australia, New Zealand, South Korea, Singapore, Saudi Arabia, Kuwait, Brunei, Chile, Peru, Qatar, the UAE, and the rest of the world (ROW). For simplicity, we assume two factors, labor (L) and capital (K), are required to produce two types of goods, which are manufacturing products and non-manufacturing products.

We use 2018 data to build a benchmark system of the numerical model. Factor input and industry output data are mainly derived from the World Development Index (WDI) database. We use GDP data to represent the total output of each country, and we indirectly calculate the output of non-manufacturing industries using the share of services and agriculture in their GDP, and the output of manufacturing industries using the share of manufacturing in their GDP. The capital factor is calculated from the data of GDP/capital ratio, and the labor factor depends on the labor income (wages) of each industry. Output data and trade data can indirectly calculate the consumption demand of domestic products, of which trade represents products consumed abroad; the data comes from the UN Comtrade database. In terms of consumption, output data and trade data indirectly calculate the demand for domestic products, where trade represents the consumption of foreign products; the data comes from the UN Comtrade database. The internal currency demand is determined by its ceiling and trade imbalance. We set the ceiling at 1 trillion, which can ensure that the trade imbalance of all countries plus this value is greater than 0. For ROW countries, the data is obtained from the world total minus all other countries.

Product substitution elasticity and factor substitution elasticity in consumption and production functions cannot be directly calculated from calibration. There are usually two methods of evaluation: one uses large sample historical statistics for estimation, and the other is to draw from other literature. Considering that our model contains many countries, the work of estimating elasticity in the production and consumption functions for each country’s industry is considerable, and the estimation of historical data cannot represent the current reality. Therefore, we refer to other literature (Betina et al., 2006; Whalley and Wang, 2010) and set all elastic values to 2. We also perform sensitivity tests on the elasticities of simulation results.

At the level of tariff and non-tariff barriers, tariff data comes from the WTO tariff statistics database, and non-tariff barriers are determined indirectly by trade costs minus tariffs. We calculate trade costs following the approaches in Novy (2013), and trade data required for the calculation come from the UN Comtrade database. GDP data and value-added data of the service industry come from the World Bank’s WDI database.

Based on the reference data system, the parameters of the theoretical model are calibrated. For the calibration method, we refer to Shoven and Whalley (1992) and use the reference data system to reverse calculate the parameter values. The specific method is to treat the variables of the model as parameters and the parameters as variables. After solving the equilibrium of the model in the reverse direction, the parameters of the model can be obtained from the equilibrium solution.

As for COVID-19’s trade impact parameters, which mainly include the trade cost increasing rate and the labor input reducing rate, we use China’s trade data from January to April of 2020 to calibrate them. Statistics from the China National Bureau of Statistics show that China’s total value of trade from January to April 2020 dropped by 4.9%–9.07 trillion yuan due to the pandemic. Exports totaled 4.74 trillion yuan, down 6.4%. Imports totaled 4.33 trillion yuan, down 3.2%. The trade surplus was 415.7 billion yuan, down 30.4%. Using this trade influence data, we calibrate the trade cost increasing rate parameters and labor input reducing rate parameters in production.

4. Simulation results

With continuous increases in the number of confirmed cases worldwide, the COVID-19 pandemic is still in a hot stage, which has brought significant uncertainty to world trade. Using the above calibrated numerical GE model, we simulate the effects of COVID-19 on trade in different countries, including the EU, the US and some Asian countries within China.
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Table 1

| Country | Trade Influence | Export | Import | Trade Double Influence | Export | Import | Trade Triple Influence | Export | Import |
|---------|-----------------|--------|--------|------------------------|--------|--------|------------------------|--------|--------|
| US      | -22.669         | 17.645 | -37.085 | -22.783                | 17.436 | -37.166 | -22.881                | 17.256 | -37.234 |
| EU      | -9.993          | -10.488 | -9.482  | -10.098                | -10.543 | -9.639  | -10.19                 | -10.596 | -9.772  |
| China   | -13.444         | -14.522 | -12.153 | -15.578                | -16.721 | -14.269 | -17.34                 | -18.509 | -15.939 |
| Japan   | -10.29          | -15.676 | -4.058  | -10.638                | -15.963 | -4.476  | -10.927                | -16.21  | -4.814  |
| India   | -6.789          | -19.105 | 4.434   | -6.849                 | -19.044 | 4.264   | -6.901                 | -19.003 | 4.126   |
| Brazil  | -11.666         | -26.952 | 24.422  | -12.199                | -27.414 | 23.725  | -12.659                | -27.826 | 23.153  |
| Russia  | -11.154         | -20.172 | 15.566  | -11.376                | -20.244 | 14.899  | -11.572                | -20.32  | 14.347  |
| Mexico  | -13.922         | -15.624 | -12.118 | -14.017                | -15.484 | -12.462 | -14.107                | -15.386 | -12.751 |
| Australia | -6.264        | -22.700 | 21.224  | -7.040                 | -23.413 | 20.342  | -7.7                   | -24.033 | 19.616  |
| Canada  | -15.097         | -19.586 | -10.007 | -15.185                | -19.519 | -10.269 | -15.267                | -19.48  | -10.488 |
| Korea   | -6.261          | -14.596 | 5.31    | -6.448                 | -14.782 | 5.123   | -6.572                 | -14.92  | 5.018   |
| New Zealand | -13.919      | -29.867 | 9.874   | -14.539                | -30.376 | 9.09    | -15.077                | -30.835 | 8.434   |
| Singapore | -8.157         | -15.945 | 3.652   | -8.161                 | -15.852 | 3.502   | -8.161                 | -15.779 | 3.391   |
| Thailand | -10.885        | -23.328 | 7.358   | -11.013                | -23.404 | 7.154   | -11.103                | -23.469 | 7.029   |
| Malaysia | -12.422        | -24.051 | 7.073   | -12.519                | -24.061 | 6.833   | -12.584                | -24.071 | 6.674   |
| Vietnam | -9.456         | -19.196 | 3.502   | -9.579                 | -19.235 | 3.269   | -9.661                 | -19.271 | 3.124   |
| Philippines | -15.659        | -40.917 | 15.626  | -16.024                | -41.034 | 14.953 | -16.338                | -41.15  | 14.393  |
| Indonesia | -10.559        | -30.324 | 24.6    | -10.998                | -30.546 | 23.776  | -11.375                | -30.751 | 23.092  |
| ROW     | -8.202          | -7.664  | -8.706  | -8.578                 | -8.018  | -9.103  | -8.908                 | -8.329  | -9.449  |
| WORLD   | -12.467         | -12.467 | -12.467 | -12.972                | -12.972 | -12.972 | -13.395                | -13.395 | -13.395 |

Source: compiled by authors.

In order to comprehensively explore the trade effects of the pandemic, we set five different scenarios for analysis: (I) trade impacts of the pandemic in China; (II) trade impacts of the pandemic in the EU; (III) trade impacts of the pandemic in the US; (IV) joint trade effects of the pandemic in the EU and US; and (V) joint trade effects of the pandemic globally.

4.1. Trade impacts of the epidemic in China

The outbreak of COVID-19 in China hurts all main countries. The US trade is hurt the most, followed by China and the EU. Specifically, China’s trade decreases by 13.444 %, its export decreases by 14.522 %, and its import decreases by 12.153 %. At the same time, the EU export decreases by 10.488 %, imports by 9.482 %, and trade by 9.993 %. Trade in the US decreases by 22.669 %, import decreases by 37.085 %, but export increases by 17.645 % (see Fig. 1).

Table 1 summarizes the impact on major developed and developing countries. Under the influence without policy intervention, the results show that Asian countries are significantly hurt by the pandemic in China. With them, Philippines is prominent; Malaysia, Thailand, Indonesia, and Japan are moderate; Vietnam, Singapore, Korea and India are comparatively weak. Without intervention, the pandemic in China has caused trade in all countries to suffer varying degrees of loss. However, the trade gains and losses of countries are asymmetric. The main reason for the negative impact on these countries...
is that pandemic interferes with the normal functioning of China’s export enterprises, along with trade restrictions in foreign countries and the sharp reduction in exports leading to supply-side disruption. The countries on the import side cannot find import alternatives in the short term to cope with China’s temporary supply shortage, so related industries in these countries are also affected and their exports are constrained. On the other hand, imports in Asian countries have shown growth, with the Indonesia and Philippines seeing obvious import increases, up 24.6 % and 15.626 % respectively.

We take the influence with trade disruption as an example to show the effects to Asian countries. The trade of Philippines, Japan and Indonesia separately decrease by 25.261 %, 24.682 %, and 23.128 %, these three countries are suffered the most. In contrast, India suffers the least trade losses, only 9.615 %. As the world’s largest exporter and second-largest importer, the pandemic’s impacts in China will undoubtedly decrease global trade. The simulation result shows that the impact of the pandemic in China has caused a global trade loss of 12.467 %. In addition, the deterioration of the outbreak will exacerbate trade losses, but they will be less volatile.

Table 2
Trade Impacts of the Epidemic in the EU (% change).

| Country   | Trade Influence Level as in China | Export Influence Level as in China | Import Influence Level as in China | Trade Influence Level According to the Number of Confirmed Cases | Export Influence Level with Trade Disruption | Import Influence Level with Trade Disruption |
|-----------|----------------------------------|-----------------------------------|-----------------------------------|---------------------------------------------------------------|---------------------------------------------|---------------------------------------------|
| US        | -23.001                          | 17.015                            | -37.311                           | -23.759                                                      | 15.592                                      | -37.831                                     |
| EU        | -15.24                           | -16.156                           | -14.294                           | -24.233                                                      | -25.764                                     | -22.652                                     |
| China     | -11.713                          | -12.687                           | -10.546                           | -12.481                                                      | -13.388                                     | -11.395                                     |
| Japan     | -10.405                          | -15.77                            | -4.197                            | -10.622                                                      | -15.946                                     | -4.462                                      |
| India     | -6.995                           | -19.314                           | 4.231                             | -7.117                                                       | -19.376                                     | 4.054                                       |
| Brazil    | -11.877                          | -26.93                            | 23.664                            | -12.235                                                      | -27.14                                     | 22.958                                      |
| Russia    | -11.995                          | -20.868                           | 14.296                            | -12.52                                                       | -21.242                                     | 13.325                                      |
| Mexico    | -14.067                          | -15.81                            | -12.218                           | -14.178                                                      | -15.823                                     | -12.433                                     |
| Australia | -6.206                           | -22.274                           | 20.667                            | -6.549                                                       | -22.413                                     | 19.982                                      |
| Canada    | -15.324                          | -19.798                           | -10.251                           | -15.472                                                      | -19.86                                     | -10.496                                     |
| Korea     | -6.335                           | -14.596                           | 5.134                             | -6.46                                                       | -14.683                                     | 4.957                                       |
| New Zealand | -14.055                        | -20.714                           | 9.308                             | -14.415                                                      | -20.883                                     | 8.664                                       |
| Singapore | -8.026                           | -15.636                           | 3.515                             | -7.964                                                       | -15.441                                     | 3.374                                       |
| Thailand  | -10.915                          | -23.335                           | 7.294                             | -10.991                                                      | -23.375                                     | 7.165                                       |
| Malaysia  | -12.574                          | -24.174                           | 6.875                             | -12.69                                                       | -24.235                                     | 6.666                                       |
| Vietnam   | -9.715                           | -19.558                           | 3.379                             | -9.895                                                       | -19.746                                     | 3.211                                       |
| Philippines | -15.824                        | -41.171                           | 15.572                            | -16.07                                                       | -41.335                                     | 15.224                                      |
| Indonesia | -10.602                          | -30.488                           | 24.773                            | -10.827                                                      | -30.664                                     | 24.461                                      |
| ROW       | -9.124                           | -8.505                            | -9.702                            | -9.742                                                       | -9.073                                     | -10.367                                     |
| WOLRD     | -13.334                          | -13.334                           | -13.334                           | -13.994                                                      | -13.994                                     | -13.994                                     |

Source: compiled by authors.
4.2. Trade impacts of the epidemic in the EU

To simulate the trade impacts of the pandemic in the EU, we assume four scenarios: the first is the double influence level as in China; the second scenario is the triple influence level as in China; the third scenario is that the influence level according to the number of confirmed cases; the fourth is that the influence with trade disruption. Fig. 2 shows the results of the third scenario. We find that the EU is the worst affected, with trade losses of 24.233%, export losses of 25.764%, and import losses of 22.652%. The pandemic in the EU causes China to lose 12.481% in total trade, 13.388% in export, and 11.395% in import. The US trade and import lose 23.759% and 37.831% respectively, and export benefits increase by 15.592%.

The COVID-19 pandemic spread rapidly in the EU, and a large number of foreign trade enterprises are facing order cancellations or delays; trade uncertainty accelerates business crisis. The EU has a vast international market for its important trade position, so the impact of the outbreak is bound to intensify for other developed and developing countries. Our simulation results in Table 2 show that the trade of all countries is damaged, and exports decrease more than imports. Focusing on the total trade, it is clear that Asian countries are affected differently among the various scenarios of the epidemic in the EU, if these countries face the trade disruption, their trade losses will be the most. The trade shock has its largest impact on the Philippines and China. The loss to the Philippines of 20.133% of trade is, however, larger than the corresponding loss of 18.513% for China. Malaysia is the next-most-affected region, losing 16.298% of trade, followed closely by Japan and Vietnam, with the loss of 15.787% and 15.184%, respectively. Meanwhile, countries with more trade with the EU are hurt more. Additionally, as the pandemic influence level increases, the negative effects are larger. The negative impacts of the epidemic in the EU have larger effects on the world than China. Specifically, under the double and triple influence level as in China, world trade will fall by 13.334% and 13.994% separately (shown in Table 2).

4.3. Trade impacts of the epidemic in the US

We make the same assumptions for the US as we made for the EU and set four scenarios. Under the influence level according to the number of confirmed cases, the EU, and China are both greatly hurt, with the US hurting the most. Specifically, the US trade will decrease by 29.595%, import decreases by 41.78%, and export increases by 4.481%. A possible reason for the increase in export is that the US has an export competitive advantage in the international trade market due to its huge market, advanced technology, and high productivity (Abdulhamid and Ahmed, 2019). Both China and the EU, the main trading partners of the US, are affected by their imports and exports, with trade losses of 12.709% and 11.406%, respectively (shown in Fig. 3).

For the Asian region, although some countries lose in total trade and export but can gain in import. We take the double influence level of the epidemic in China as an example, the trade of the Philippines and Malaysia decrease by 15.84% and 12.548%, but their imports gain 15.737% and 7.014%. The effects of the triple influence level as in China on Asian countries are nearly the same as the simulation results of the double influence level as in China. In addition to Asian countries, imports from other developed and developing countries also increase to varying degrees. In the context of the impact of COVID-19, the reason why some countries’ imports rise instead of falling may be trade diversion and the price effect. In general, countries with closer trade relations with the US are hurt more than other countries. For the trade effects on the world, the influence with trade disruption hurt it more compared with the real influence situation (see Table 3).

**Fig. 3.** Trade Impacts of Epidemic in the US under Real Influence Situation to main Countries. Source: compiled by authors.
### Table 3
Trade Impacts of the Epidemic in the US (% change).

| Country | Trade Double Influence Level as in China | Export Export | Import Import | Trade Triple Influence Level as in China | Export Export | Import Import | Trade Influence Level According to the Number of Confirmed Cases | Trade Influence with Trade Disruption |
|---------|-----------------------------------------|---------------|--------------|-----------------------------------------|---------------|--------------|---------------------------------------------------------------|---------------------------------------|
| US      | -25.153                                 | 12.915        | -38.767      | -26.425                                 | 10.499        | -39.628      | -29.595                                                      | 4.481                                 |
| EU      | -10.442                                 | -10.983       | -9.883       | -10.71                                 | -11.249       | -10.153      | -11.406                                                      | -11.942                               |
| China   | -11.784                                 | -12.82        | -10.543      | -12.041                                 | -13.086       | -10.788      | -12.709                                                      | -13.781                               |
| Japan   | -10.613                                 | -16.074       | -4.293       | -10.938                                 | -16.406       | -4.609       | -11.781                                                      | -17.275                               |
| India   | -7.168                                  | -19.704       | 4.255        | -7.378                                 | -19.96        | 4.087        | -7.926                                                      | -20.631                               |
| Brazil  | -11.821                                 | -27.001       | 24.022       | -12.157                                 | -27.254       | 23.49        | -13.026                                                      | -27.915                               |
| Russia  | -11.171                                 | -20.287       | 15.837       | -11.287                                 | -20.376       | 15.645       | -11.587                                                      | -20.613                               |
| Mexico  | -14.705                                 | -16.374       | -12.936      | -15.153                                 | -16.689       | -13.524      | -16.191                                                      | -17.362                               |
| Australia | -5.983                                 | -22.288       | 21.286       | -6.223                                 | -22.439       | 20.896       | -6.841                                                      | -22.834                               |
| Canada  | -15.714                                 | -19.981       | 10.876       | -16.078                                 | -20.158       | -11.45       | -16.853                                                      | -20.419                               |
| Korea   | -6.414                                  | -14.733       | 5.135        | -6.581                                 | -14.892       | 4.957        | -7.006                                                      | -15.304                               |
| New Zealand | -13.923                              | -29.838       | 9.823        | -14.225                                 | -30.075       | 9.424        | -14.994                                                      | -30.688                               |
| Singapore | -8.377                               | -16.143       | 3.401        | -8.483                                 | -16.192       | 3.206        | -8.762                                                      | -16.325                               |
| Thailand | -10.951                                | -23.465       | 7.398        | -11.047                                 | -23.571       | 7.316        | -11.29                                                      | -23.844                               |
| Malaysia | -12.548                                | -24.216       | 7.014        | -12.655                                 | -24.301       | 6.87         | -12.933                                                      | -24.525                               |
| Vietnam | -9.68                                  | -19.609       | 3.529        | -9.847                                 | -19.828       | 3.432        | -10.283                                                      | -20.403                               |
| Philippines | -15.84                               | -41.333       | 15.737       | -16.099                                 | -41.585       | 15.467       | -16.765                                                      | -42.239                               |
| Indonesia | -10.586                              | -30.558       | 24.944       | -10.809                                 | -30.776       | 24.711       | -11.383                                                      | -31.342                               |
| ROW     | -8.002                                 | -7.486        | -8.484       | -8.099                                 | -7.582        | -8.581       | -8.327                                                      | -7.81                                 |
| WORLD   | -12.708                                | -12.708       | -12.708      | -13.079                                 | -13.079       | -13.079      | -14.008                                                      | -14.008                               |

Source: compiled by authors.

![Fig. 4. Trade Impacts of the Epidemic in the EU and US under Real Influence Situation to Main Countries. Source: compiled by authors.](image)

### 4.4. Joint trade effects of the epidemic in the EU and the US

As important trading partners of most countries, the European and American shutdowns of some production lines due to the coronavirus has led to many supply shortages of upstream products in the global value chain. The impact on industry sectors with long chains is particularly obvious. Fig. 4 and Table 4 reveal that the combined trade shocks from outbreaks in the EU and the US are greater than those of the previous three scenarios. We firstly analyze the real influence situation to main countries, simulation results show that the US is significantly hurt by the joint effects of the epidemic in the EU and the US, trade and import separately decrease by 30.538 % and 42.429 %, but its export still increases 2.715 % (see Fig. 4).

We secondly analyze the effects on Asian countries. The trade shocks through the industrial chain and cross-border investment channels spread to Asian countries, resulting in different degrees of negative impacts. If the severity of the epidemic situation in the US is three times that of China, except for Korea, India, and Singapore, the trade losses of other Asian countries will be more than 10 %. For example, China’s trade decreases by 12.717 %, export decreases by 13.701 %, and import decreases by 11.539 %; Japan’s trade decreases by 11.629 %, export by 16.977 %, and import by 5.44 %. From a worldwide
## Table 4
Joint Trade Impacts of the Epidemic in both the EU and the US (% change).

| Country  | Trade Influence Level as in China | Export Influence Level as in China | Import Influence Level as in China | Trade Influence Level According to the Number of Confirmed Cases | Export Influence Level According to the Number of Confirmed Cases | Import Influence Level According to the Number of Confirmed Cases | Trade Influence with Trade Disruption | Export Influence with Trade Disruption | Import Influence with Trade Disruption |
|----------|----------------------------------|-----------------------------------|-----------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| US       | -25.565                          | -12.142                           | -25.565                           | -27.008                                                       | 9.405                                                        | -40.029                                                       | -30.538                               | -100                                  | -100                                  |
| EU       | -15.756                          | -16.669                           | -15.756                           | -18.544                                                       | -19.641                                                      | -17.411                                                      | -25.469                               | -26.994                               | -23.894                               |
| China    | -12.244                          | -13.239                           | -12.244                           | -12.717                                                       | -13.701                                                      | -11.539                                                      | -13.945                               | -14.911                               | -12.788                               |
| Japan    | -11.085                          | -16.465                           | -11.085                           | -11.629                                                       | -16.977                                                      | -5.44                                                        | -13.036                               | -18.319                               | -6.922                                |
| India    | -7.436                           | -19.852                           | -7.436                            | -7.768                                                       | -20.17                                                      | 3.533                                                        | -8.63                                 | -21.015                               | 2.655                                 |
| Brazil   | -12.586                          | -27.466                           | -12.586                           | -13.281                                                       | -27.931                                                      | 21.309                                                      | -15.06                                | -29.147                               | 18.202                                |
| Russia   | -12.244                          | -21.061                           | -12.244                           | -12.884                                                       | -21.525                                                      | 12.719                                                      | -14.488                               | -22.721                               | 9.905                                 |
| Mexico   | -14.952                          | -16.422                           | -14.952                           | -15.512                                                       | -16.75                                                      | 14.2                                                        | -16.844                               | -17.476                               | -16.174                               |
| Australia| -6.725                           | -22.598                           | -6.725                            | -7.311                                                       | -22.89                                                      | 18.743                                                      | -8.799                                 | -23.656                               | 16.046                                |
| Canada   | -16.035                          | -20.129                           | -16.035                           | -16.548                                                       | -20.368                                                      | -12.215                                                      | -17.707                               | -20.802                               | -14.196                               |
| Korea    | -6.675                           | -14.921                           | -6.675                            | -6.967                                                       | -15.169                                                      | 4.419                                                        | -7.711                                 | -15.82                                | 3.547                                 |
| New Zealand | -14.71                         | -30.225                           | -14.71                            | -15.372                                                       | -30.633                                                      | 7.397                                                        | -17.046                               | -31.697                               | 4.814                                 |
| Singapore | -8.247                          | -15.737                           | -8.247                            | -8.291                                                       | -15.589                                                      | 2.776                                                        | -8.414                                 | -15.236                               | 1.93                                 |
| Thailand | -11.109                          | -23.551                           | -11.109                           | -11.282                                                       | -23.697                                                      | 6.921                                                        | -11.717                               | -24.084                               | 6.414                                 |
| Malaysia | -12.795                          | -24.351                           | -12.795                           | -13.019                                                       | -24.496                                                      | 6.225                                                        | -13.596                               | -24.892                               | 5.342                                 |
| Vietnam  | -10.063                          | -20.013                           | -10.063                           | -10.411                                                       | -20.424                                                      | 2.91                                                        | -11.318                               | -21.509                               | 2.239                                 |
| Philippines | -16.387                        | -41.716                           | -16.387                           | -16.894                                                       | -42.135                                                      | 14.37                                                        | -18.18                                | -43.222                               | 12.838                                |
| Indonesia | -11.086                          | -30.961                           | -11.086                           | -11.536                                                       | -31.356                                                      | 23.722                                                      | -12.682                               | -32.382                               | 22.361                                |
| ROW      | -9.318                           | -8.699                            | -9.318                            | -10.037                                                       | -9.366                                                      | 10.664                                                      | -11.844                               | -11.044                               | -12.592                               |
| WORLDS   | -14.084                          | -14.084                           | -14.084                           | -15.103                                                       | -15.103                                                      | -15.103                                                      | -17.641                               | -17.641                               | -17.641                               |

Source: compiled by authors.

Fig. 5. Trade Impacts of the Epidemic in the World under Real Influence Situation to Main Countries. Source: compiled by authors.

The perspective, the incremental effects of coronavirus outbreaks in the advanced economies of the EU and the US have exacerbated the economic impact of the pandemic on global trade (see Table 4).

### 4.5. Joint trade effects of the epidemic in the world

At present, COVID-19 has spread around the world. Infection rates are rising in the US, Brazil, and India and are escalating in South America and Africa. The global spread of the pandemic will further increase the negative impact on trade. Joint trade effects of the pandemic globally are reported in Fig. 5 and Table 5.

We take the real influence level according to the number of confirmed cases as an example to specifically show the effect on Asian countries. In terms of exports, the Asian countries in Table 5, such as the Philippines, Indonesia, and Malaysia suffer more losses than other countries, where exports decrease by 30.793 %, 24.235 %, and 22.492 %, respectively. In terms of imports, in addition to Indonesia, most Asian countries also experience varying degrees of losses. Nevertheless, some developing countries do not have the capacity to detect viruses on a large scale because of poor infrastructure and inadequate medical resources. As the COVID-19 pandemic continues to spread to these countries, whether total trade will continue to
null
Given that there are five simulation scenarios, we only report sensitivity analysis results for the scenario of joint trade impacts of the pandemic in the world. The process of sensitivity analysis is to set the elasticity values from 1.5 to 4.5; the values are 1.5, 2.5, 3.5, and 4.5, respectively. The sensitivity analysis results in Table 6 reveal that with the increase of elastic value, there is a gradual decrease in trade losses as a whole, indicating that elasticity and the impact of the pandemic on global trade are negatively sensitive. However, the change in trade losses is not large, which means that the simulation results and conclusions are reliable. The sensitivity analysis of elasticity proves the credibility of all numerical simulation results in this paper.

Considering that the direct impact of the epidemic on trade is the increase of non-tariff barriers, our model mainly analyzes the changes of non-tariff barriers on trade. To better supplement, we have added a comparative analysis of tariff barriers and non-tariff barriers in the sensitivity analysis, as shown in Table 7. For simplicity, we re-calibration and re-simulation the impacts of the epidemic on trade for tariff measures and non-tariff measures in two scenarios. Comparing these results with different situations, we find that the effects of tariff measures and non-tariff measures are nearly the same, changes are just in number values. Therefore, these prove that the above simulation results are reliable and robust.

5. Conclusions and remarks

We build a 26-country GE model with trade cost and endogenous trade imbalance, and we use 2018 data to construct a benchmark dataset and get a numerical GE model to simulate the trade effects of COVID-19 in China, the EU, the US, and the world. Our simulation results reveal that trade and exports will suffer in all countries as a result of the pandemic, but some countries will gain in imports because of trade diversion and price increasing effects. Comparatively, negative effects of the pandemic in the EU are greater than those seen in the US, and the negative effects in the US are greater than those seen in China. Negative trade effects of the pandemic globally are the greatest. As the epidemic deepens, the negative impact on trade will be increase. In the global pandemic context, the US trade will be hurt the most, seeing nearly 1.5 times that of the world average trade impact.

Although the global spread of the COVID-19 pandemic has amplified protectionism and caused asymmetric shocks to trade among countries, it cannot be regarded as a justification for anti-globalization. The emergence of the pandemic only indirectly exposes the present problems of globalization. This is not a "bad thing," because the trend of globalization is a curve growth, which is difficult to contain. Governments and scholars should reflect on the development of globalization by promoting the establishment and optimization of their own systems, reducing the impact of sudden external events on domestic economies and trade. In the post-pandemic era, how to reconstruct the global supply chains and promote the development of emerging fields (such as the digital economy) is an urgent problem to solve through economic recovery policies, and how to quantify these policy effects can be the focus of further study.

### Table 7
Comparing Results of Tariff and Non-tariff Increase with the Scenario of Joint Trade Impacts of the Epidemic in the World (% change).

| Country | Trade Tariff Measuring Triple Influence Level as in China | Trade Tariff Measuring Triple Influence Level According to the Number of Confirmed Cases | Import Tariff Measuring Triple Influence Level as in China | Import Tariff Measuring Triple Influence Level According to the Number of Confirmed Cases |
|---------|---------------------------------|-------------------------------------------------|---------------------------------|-------------------------------------------------|
| US      | -25.415                         | 12.402                                          | -38.938                         | 26.609                                          |
| EU      | -14.568                         | -15.103                                         | -14.015                         | 18.379                                          |
| China   | -12.468                         | -12.852                                         | -12.007                         | -12.357                                         |
| Japan   | -14.227                         | -19.561                                         | 8.055                           | 16.471                                          |
| India   | -11.982                         | -23.569                                         | -1.424                          | -21.977                                         |
| Brazil  | -16.13                          | -30.377                                         | 17.512                          | -19.402                                         |
| Russia  | -15.94                          | -24.468                                         | 9.329                           | -19.168                                         |
| Mexico  | -17.969                         | -18.811                                         | -16.015                         | -20.649                                         |
| Australia | -9.707                         | -25.698                                         | 17.038                          | -12.772                                         |
| Canada  | -18.938                         | -23.425                                         | 13.849                          | -12.925                                         |
| Korea   | -8.759                          | -18.228                                         | 4.386                           | -19.97                                          |
| New Zealand | -17.838                     | -34.009                                         | 6.289                           | -21.824                                         |
| Singapore | -12.631                       | -20.376                                         | -0.887                          | -19.494                                         |
| Thailand | -15.394                        | -27.077                                         | 1.737                           | -19.113                                         |
| Malaysia | -17                             | 28.29                                          | 1.929                           | -18.113                                         |
| Vietnam | -13.644                        | -22.779                                         | 1.467                           | -16.193                                         |
| Philippines | -19.433                       | -44.202                                         | 11.247                          | -24.055                                         |
| Indonesia | -14.36                         | -33.467                                         | 19.629                          | -20.869                                         |
| ROW     | -12.132                         | -11.756                                         | 12.483                          | -14.014                                         |
| WORLD   | -15.575                         | -15.575                                         | 15.575                          | -17.414                                         |

Source: compiled by authors.
Appendix A

Table A1

The overall structure of the general equilibrium equation.

| Category | Equation | Explanation |
|----------|----------|-------------|
| Production | $Q^*_l = \sigma^*_l \sum_i [\delta^*_l (F^*_l)^{\alpha^*_l} (P^*_l)^{\beta^*_l}]$ | where $Q^*_l$ denotes the output of country $i$ in industry $l$, industries divide into manufacturing and non-manufacturing. $F^*_l$ denotes the factor input, labor and capital. $\delta^*_l$ denotes the share of factor input. $\sigma^*_l$ denotes factor substitution elasticity. $P^*_l$ denotes the factor price. |
| Consumption | $U_i(X_i) = \sum_j [\alpha^*_i (X_i)^{\gamma^*_i} (P^*_i)^{\delta^*_i}]$ | where $X^*_i$ denotes the consumer demand in country $i$. $\alpha^*_i$ denotes the consumption share of product $l$. $X^*_i$ denotes the consumption demand of country $i$ for product $l$ produced by country $i$. $P^*_i$ denotes the consumer price, and $\beta^*_i$ denotes the share of country $i$ that consumes products from country $i$. $P^*_i$ denotes the price of composite product $l$ consumed in country $i$. |
| Equilibrium | a. $\sum_i F^*_i = F_b$ | where equation a indicates factor market clearing; equilibrium equation b indicates product market clearing; equation c indicates trade equilibrium; and equation d indicates zero profit condition under perfect competition. |
|          | b. $Q^*_l = \sum_i x^*_l$ | |
|          | c. $\sum_i Y_i = 0$ | |
|          | d. $P^*_i = \sum_i w^*_i F^*_i$ | |

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