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# The economic effects of export restrictions imposed by major grain producers

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**Abstract:** This paper uses the global trade analysis project (GTAP) to evaluate the impact of grain export restrictions on world food security during the COVID-19 epidemic. The study found that export restrictions distort world market prices, which in turn distort consumption and production, harm the interests of consumers and farmers in some countries, and threaten food security. In this regard, maintaining the convenience of the food trade is the wise choice of all countries. It is necessary to tighten the World Trade Organization (WTO) disciplines related to export restrictions, strengthen global food security governance and jointly build a community with a shared future for mankind.

**Keywords:** COVID-19; grain security; GTAP model; reform of WTO rules

The rapid spread of the COVID-19 around the world has caused significant losses to human lives and economic activities. According to the data of the Global Trade Alert (GTA), in 2020, a total of 65 countries have implemented grain export restrictions, which has threatened the food security of importing countries that rely on the international market to fill domestic grain shortage. The most essential and basic issue of food security is 'adequate supply'. In terms of quantity (Figure 1), according to the Food and Agriculture Organization of the United Nations (FAO 2021a), the total global cereal output has shown a trend of fluctuat-

ing growth in the past decade. Cereal output increased from 2.264 billion in 2010 to 2.711 billion tons in 2019, with an increase of 19.74%. In terms of overall supply and demand, the total annual grain output basically meets the total demand, while the total grain supply exceeds the total demand. But COVID-19 pandemic, locust plagues, extreme weather and other disasters will worsen global food insecurity. Countries with fragile food security can easily fall into severe food insecurity. In 2020, 720 million to 811 million people in the world will be hungry. As of July 2021, according to FAO (2021b), there are currently 45 countries in need of ex-

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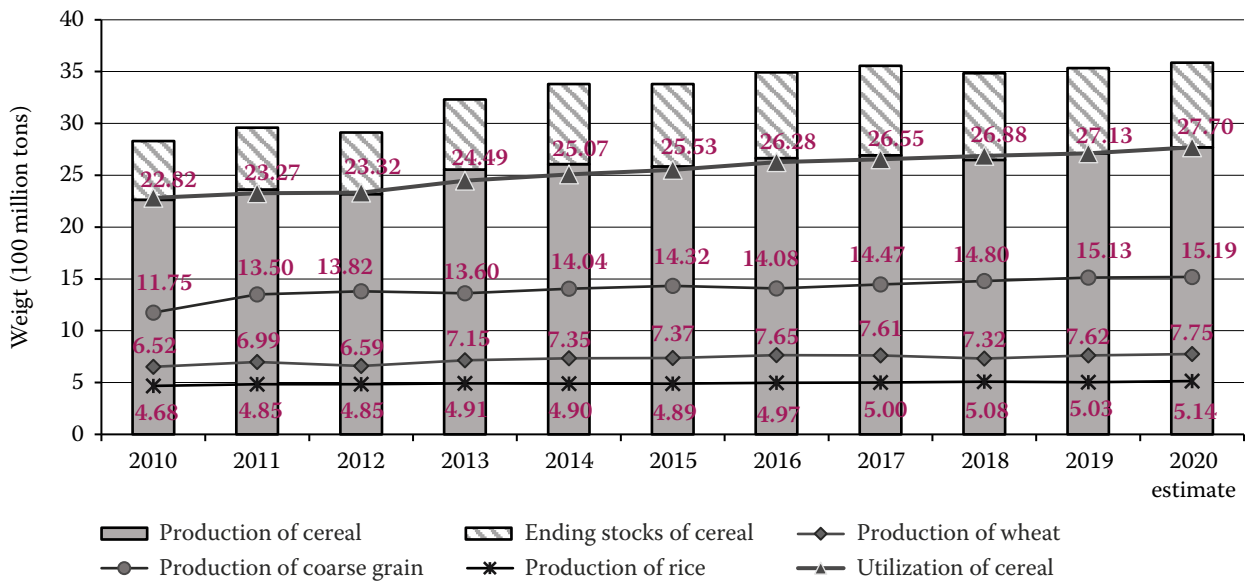


Figure 1. World grain supply and demand trend chart (2010–2020)

Source: FAO (2021a)

ternal food assistance (include 34 African countries), and they are mainly facing crises such as an exceptional shortfall in aggregate food production/supplies, widespread lack of access, or severe localized food insecurity. In order to increase the degree of visualization, we use the map vector data of Natural Earth to display these countries in Figure 2 (Nature Earth 2009).

The World Trade Organization (WTO) rules on grain export restrictions are embodied in Article 12 of the

'Agricultural Agreement', requiring any member to fully consider the impact of such restrictions on the food security of importing members in accordance with Article 11, paragraph 2(a) of the General Agreement on Tariffs and Trade (GATT) 1994. Except for developing countries that are not net exporters of a specific food, members must notify the Agriculture Committee before imposing new export restrictions on food, and consult with affected members upon request. In fact,

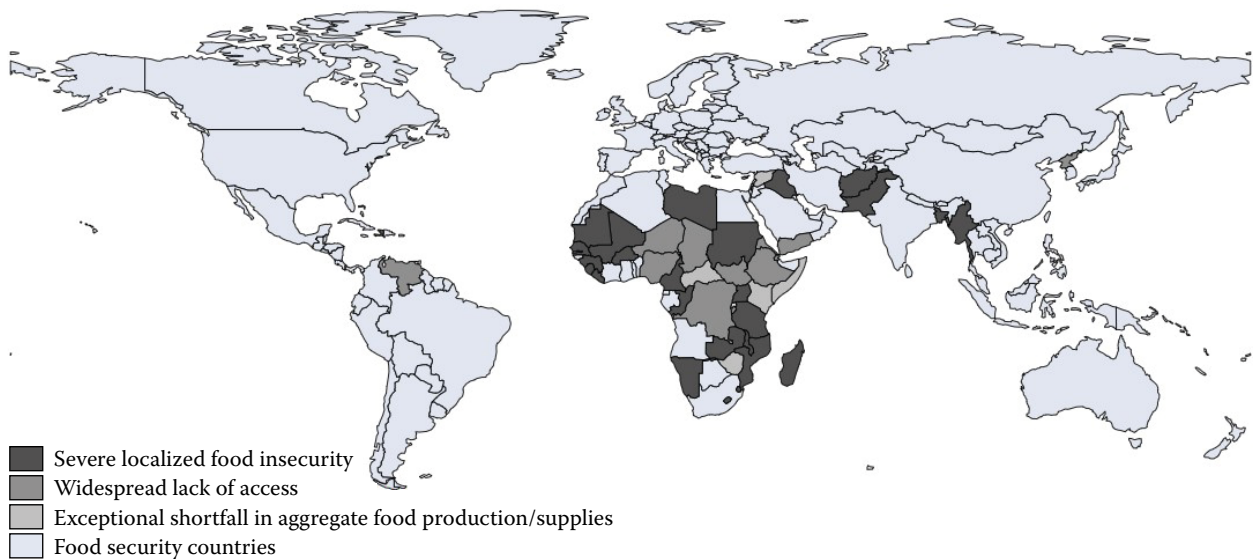


Figure 2. Country distribution map of facing crises such as an exceptional shortfall in aggregate food production/supplies, widespread lack of access, or severe localized food insecurity

Source: The list of food insecure countries comes from FAO (2021b); the map data comes from Natural Earth (2009)

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very few members actually fulfil the obligation of consultation and notification. This discipline is very broad and does not have strict and complete regulations. There are defects such as unclear concepts (Feng and Lin 2013), poor operability, and no specific punishment measures, which makes the rule unable to achieve the regulatory effect. It is, precisely, because the original shortcomings of WTO grain export restriction rules have not been substantially improved, more and more regional trade agreements have made more stringent concerns about this discipline and have made more complete and harsh regulations, such as the Common Market for Eastern and South Africa (COMESA) and the U.S.-Mexico-Canada Agreement (USMCA). Finally, they played a significant regulatory effect. However, it can only restrict members within the framework of regional cooperation, and this one-size-fits-all rule will seriously damage the interests of countries with relatively fragile food security. Therefore, regional trade agreements must follow WTO principles, and the two complement each other to jointly manage food security (Qing and Wenxiang 2019).

Export restrictions have a major impact on grain security. During the 2008 grain crisis, more than 30 countries adopted export restrictions, and the results showed that trade restrictions eventually turned into serious price crises. From the results of related research, there is a mutual promotion between the export restrictions of grain and the international price of grain (Headey 2011; Martin and Anderson 2011; Rude and An 2015; Sun et al. 2015; Glauber et al. 2020). With the spread of COVID-19 and its economic impact in the world, the increased cost of the interruption of international logistics networks has promoted the increase in grain consumer prices, and has severely damaged the 'purchasing power' of grain in importing countries, especially low-income countries, and exacerbated the grain crisis. The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT model) is used to simulate the impact of export bans on rice and wheat markets on grain prices and hunger. The results show that grain prices may rise sharply. It is estimated that as many as 18 million people worldwide will face long-term hunger in 2020 (Sulser and Dunston 2020). Grain export restrictions have distorted market supply and demand, leading to a worldwide grain crisis through the price transmission mechanism.

In theory, export restrictions will cause price distortions in the form of reduced welfare, causing local farmers to lose more losses due to falling domestic

prices than local consumers' gains (Liefert et al. 2012). When many countries impose export restrictions, their actions will further exacerbate price surges, and in fact, the policies will be counterproductive because the markets of various countries continue to track international prices (Martin and Anderson 2010; Gotz et al. 2012). This article provides new empirical evidence from multiple areas under the new crown epidemic that export bans do not always have the effects that governments and policy analysts think they do.

In addition, the existing literature mainly analyzes the rule defects of grain export restriction measures and the relationship between the measures and grain prices. There is also a lack of simulations of the economic effects of various specific grain export restrictions implemented by countries during the new crown epidemic, including export taxes, export quotas and export bans. And there is no comprehensive analysis of macroeconomic effects and industrial effects. Therefore, this article uses the global trade analysis project (GTAP), comprehensively considers the above factors, and conducts a policy shock simulation test according to the scope and intensity of actual implementation. While paying attention to price changes, assess the impact of food export restrictions on different economies under the epidemic from the macroeconomic and industrial levels, so as to provide reasonable suggestions for global food security governance.

## MATERIAL AND METHODS

**The multi-country multi-sector global trade model.** This paper adopts the multi-country multi-sector global trade model (GTAP) under the general equilibrium framework. This model was developed by Hertel (Hertel and Tsigas 1997) and is often used for pre-simulation and evaluation of trade policies. In this paper, export prohibition measures are one of the shock policies, but exports are endogenous in the GTAP model. In order to achieve this shock, we swap the endogenous variable of export with the exogenous variable of imported product technology. We used RunGTAP 3.69 software to conduct policy shock experiments. GTAP assumes that the market is perfectly competitive, the returns to scale are unchanged, resources are used rationally, and the optimal supply is equal to the optimal demand, forming a general equilibrium state. The general equilibrium model structure includes three aspects, namely, the minimum producer cost, the maximum consumer utility, and the clearing of the market. Export restrictions directly

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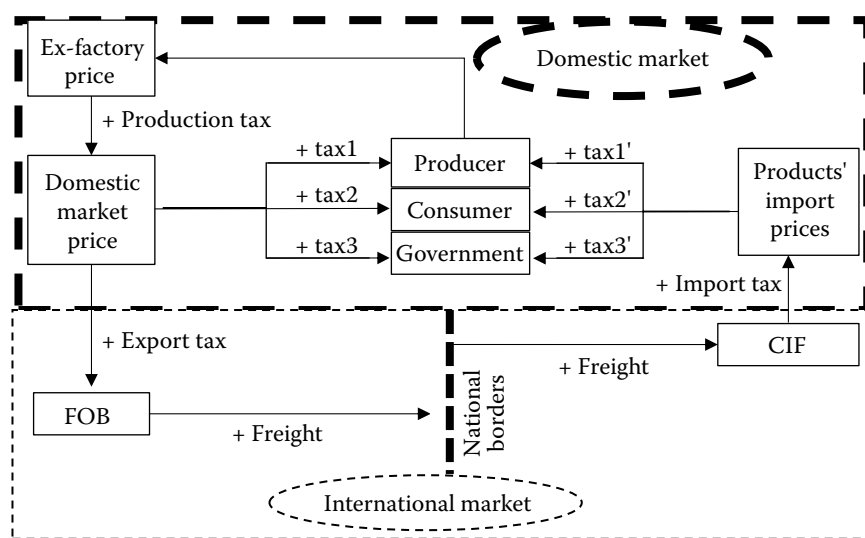


Figure 3. Mechanism of price transmission effect  
 FOB – free on board; CIF – cost insurance and freight  
 Source: Authors' own elaboration

Table 1. Export restriction measures of major grain exporting countries in 2020

| State      | Intervention type and period            | Affected object | Potentially affected products (harmonized system 6-digit or 8-digit code)   | Intensity of intervention  |
|------------|---|-----------------|---|--|
| Argentina  | export tax<br>(start date: 2020/03/05)  | rice            | 10061091, 10062010, 10062020<br>10061092  | 5%<br>6%   |
|            |   | coarse grain    | 10081090, 10082190, 10082990, 10083090,<br>10089090   | 5%   |
|            | export quota<br>(2020/12/30–2021/01/12) | coarse grain    | 100590, 100510  | 11%  |
| Russian    | export ban<br>(2020/04/14–2020/07/01)   | rice            | 100610, 100620  | –  |
|            |   | coarse grain    | 100810, 100290, 100210, 100829, 100821  | –  |
|            | export quota<br>(2020/04/01–2020/07/01) | wheat           | 100199, 100119, 100390, 100290  | –  |
| Pakistan   | export ban<br>(start date: 2020/06/10)  | coarse grain    | 1001100, 10019110, 10019120, 10019190,<br>10021000, 10031000, 10051015, 10051018,<br>1005101809, 10051090, 100590 (exclude<br>10011100, 10019110, 10019120, 10019190,<br>10021000, 10031000, 10051015, 10051018,<br>1005101809, 10051090, 100590) | 7 million tons<br>(non-Eurasian<br>Economic Union)   |
|            |   | wheat           | 100199, 100191, 100119, 100111  | –  |
|            | export quota<br>(2020/04/02–2020/09/01) | wheat           | 100119, 100199, 100191, 100111  | monthly export quotas<br>of wheat grain were set<br>at 200 000 t in April,<br>respectively; the export quota<br>of wheat for May was<br>increased to 250 000 t |
| Kazakhstan | export ban<br>(2020/04/14–2020/07/01)   | rice            | 100620, 100610  | –  |
|            |   | coarse grain    | 100290, 100210, 100821, 100829, 100810  | –  |

Source: BORA (2020); GOV.KZ (2020); GTA (2020); Mišustin (2020); PID (2020)

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affect the supply on the world market. If the supply in the world market decreases and pushes up the world price, the import prices faced by producers, consumers, and the government will change, which will affect their respective demand, and will further affect the production of industries that use the product as an intermediate product, leading to changes in output, and further will affect domestic market prices. In this way, in the global trade model, changes in exports or tariffs have a domino effect, as shown in Figure 3.

**Data and data sources.** The data uses the latest GTAP 10 database released in 2019 (GTAP 2019). The 141 countries in the database are re-divided into 20 researchable regions. They are Argentina, Ukraine, Russia, Pakistan, Kazakhstan, China, the United States, Mexico, Brazil, South Africa, food insecure Asian countries (Asia\_I), Asian food security vulnerable countries (Asia\_A), North America (NAmerica), Latin American food insecure countries (LaAm\_I), Latin American food security vulnerable countries (LaAm\_A), European food security vulnerable countries (Europe\_A), other European countries (EU\_rest), African food insecure countries (Africa\_I), African food security vulnerable countries (Africa\_A), and other countries. The basis for this classification takes into account factors such as countries that have implemented grain export restrictions for more than three months in 2020, major grain exporters of the world, food insecure countries, or food security vulnerable countries. Four countries, Argentina, Russia, Pakistan and Kazakhstan, were identified as countries that implement food export restrictions. In addition, according to research needs, the original 65 industries were re-combined into 8 departments, which are Wheat, Rice, Coarse grain, Other crops, Meat food, Processing food, Manufacturing, and Service industry.

The setting of the simulation plan is based on the GTA (2020) and the official documents of the countries (Argentina, Russia, Pakistan and Kazakhstan) that have implemented grain export restrictions, and the scope, method and extent of various grain export restrictions announced (BORA 2020; GOV.KZ 2020; Mišustin 2020; PID 2020). The specific grain export restrictions of the four countries are shown in Table 1.

## RESULTS AND DISCUSSION

**Macro impact.** Table 2 shows the changes in macroeconomic indicators. In terms of welfare levels [equivalent variation (EV)], the welfare of Argentina, Kazakhstan, and Pakistan, where food export restric-

tions are more stringent, has declined. At the same time, it has also brought different degrees of negative effects on China, the United States, Brazil, South Africa, European countries vulnerable to food security, and food insecure countries in Africa. Export restrictions are implemented to redistribute benefits to consumers. However, such interventions have resulted in welfare losses in some implementing countries. After the export ban is implemented, the products available to domestic consumers will increase, and then domestic prices will fall to absorb the increased supply, resulting in price distortions (in the simulation results, price drops have been observed after the export ban). The degree of welfare loss and price distortion depends on the price elasticity of the product (Mitra and Josling 2009). Since food is inelastic and requires a greater price drop to absorb domestic supply, restrictions on food exports will result in greater welfare losses. From the perspective of changes in GDP, the GDP of most countries or regions has declined.

Table 2. Changes in macroeconomic indicators

| Region        | EV<br>(million USD) | GDP<br>(%) | TOT<br>(%) | Y<br>(%) |
|---------------|---------------------|------------|------------|----------|
| Argentina     | -958.75             | 0.98       | 0.97       | 0.95     |
| Ukraine       | 13.39               | -0.04      | -0.01      | -0.04    |
| Russia        | 11.36               | -0.02      | 0.02       | -0.02    |
| Pakistan      | -6.06               | 0.00       | 0.02       | 0.00     |
| Kazakhstan    | -285.52             | 0.11       | 0.24       | 0.09     |
| China         | -587.36             | 0.01       | 0.03       | 0.01     |
| United States | -1 185.88           | 0.02       | 0.06       | 0.02     |
| Mexico        | 255.59              | 0.00       | -0.04      | 0.00     |
| Brazil        | -142.83             | 0.04       | 0.02       | 0.04     |
| South Africa  | -15.22              | -0.01      | 0.02       | -0.01    |
| Asia_I        | 3.66                | 0.01       | 0.02       | 0.00     |
| Asia_A        | 385.40              | -0.01      | 0.00       | -0.01    |
| North America | 209.87              | 0.00       | -0.03      | 0.00     |
| LaAm_I        | 225.06              | -0.08      | -0.10      | -0.07    |
| LaAm_A        | 71.91               | 0.05       | -0.02      | 0.05     |
| Europe_A      | -34.07              | -0.05      | 0.01       | -0.05    |
| EU_rest       | 4982                | -0.06      | -0.05      | -0.05    |
| Africa_I      | -39.83              | -0.01      | 0.01       | -0.01    |
| Africa_A      | 519.06              | -0.07      | -0.06      | -0.07    |

EV – equivalent variation; TOT – terms of trade; Y – regional household income; \_I – food insecure countries; \_A – countries that are vulnerable to food security; LaAm – Latin American; EU\_rest – other European countries

Source: Authors' results are simulated by the RunGTAP 3.69 software based on the GTAP 10 database (GTAP 2019)

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Table 3. Changes in domestic sales (QDS), prices of consumer imports (PPM) and domestic products (PPD)

| Region        | Wheat |       |       | Rice  |       |       | Coarse grain |        |       | Other crops |       |       |
|---------------|-------|-------|-------|-------|-------|-------|--------------|--------|-------|-------------|-------|-------|
|               | QDS   | PPM   | PPD   | QDS   | PPM   | PPD   | QDS          | PPM    | PPD   | QDS         | PPM   | PPD   |
| Argentina     | -0.02 | 0.68  | 0.51  | -0.09 | 0.97  | 0.78  | -0.10        | -1.06  | -0.35 | -0.12       | 0.94  | 0.60  |
| Ukraine       | 0.00  | -0.04 | -0.05 | 0.00  | -0.05 | -0.05 | -0.01        | -0.21  | -0.05 | 0.00        | -0.07 | -0.05 |
| Russia        | 0.47  | 4.21  | -0.03 | -0.19 | -0.60 | -0.47 | 0.00         | -0.15  | -0.17 | -0.21       | -0.46 | -0.13 |
| Pakistan      | -0.02 | -0.01 | -0.01 | 0.00  | 0.00  | 0.00  | -0.22        | -1.85  | -0.06 | 0.01        | 0.03  | 0.00  |
| Kazakhstan    | -0.82 | -3.97 | -1.74 | 0.11  | 1.76  | -0.57 | 0.11         | 4.87   | -0.55 | 0.18        | 0.48  | -0.55 |
| China         | 0.04  | 0.45  | 0.02  | -0.01 | 0.07  | 0.01  | -0.04        | -0.74  | 0.00  | -0.01       | -0.03 | 0.01  |
| United States | 0.04  | 0.11  | 0.07  | 0.01  | 0.10  | 0.07  | 0.43         | 8.83   | 0.11  | 0.14        | 0.29  | 0.08  |
| Mexico        | 0.39  | 0.16  | 0.02  | 0.14  | 0.10  | 0.04  | 0.08         | 0.26   | 0.03  | 0.08        | 0.18  | 0.02  |
| Brazil        | -0.22 | -0.05 | 0.04  | 0.01  | 0.39  | 0.06  | 0.85         | 23.55  | 0.16  | -0.01       | 0.08  | 0.06  |
| South Africa  | 0.06  | 0.03  | -0.01 | 0.36  | 0.15  | 0.00  | 0.06         | 1.43   | 0.00  | 0.01        | 0.02  | -0.01 |
| Asia_I        | -1.40 | -0.79 | -0.29 | 0.01  | 0.00  | 0.00  | -0.01        | -0.28  | -0.01 | 0.01        | 0.03  | 0.00  |
| Asia_A        | 0.38  | 0.31  | 0.03  | 0.00  | 0.66  | -0.04 | -1.05        | -2.63  | -0.22 | 0.00        | -0.06 | -0.03 |
| North America | -0.01 | -0.01 | -0.01 | 0.08  | 0.03  | 0.01  | -0.06        | -0.38  | -0.01 | 0.19        | 0.20  | 0.00  |
| LaAm_I        | 0.67  | 0.03  | -0.22 | -0.06 | -0.42 | -0.33 | -4.86        | -14.23 | -1.05 | -0.01       | -0.57 | -0.27 |
| LaAm_A        | -0.21 | -0.47 | -0.31 | 0.00  | 0.11  | -0.30 | -8.36        | -23.18 | -1.74 | -0.02       | -0.47 | -0.25 |
| Europe_A      | 1.94  | 1.43  | 0.26  | 0.00  | 0.21  | -0.01 | 0.04         | 0.77   | -0.02 | -0.02       | -0.04 | -0.02 |
| EU_rest       | 0.10  | 0.01  | -0.03 | 0.44  | 0.09  | -0.02 | -0.18        | -0.56  | -0.06 | 0.98        | 0.83  | 0.01  |
| Africa_I      | -0.08 | -0.04 | -0.01 | 0.00  | 0.00  | -0.01 | 0.04         | 4.00   | 0.00  | 0.00        | 0.00  | -0.01 |
| Africa_A      | -0.15 | -0.26 | -0.16 | 0.01  | -0.21 | -0.16 | -3.03        | -13.78 | -0.37 | -0.02       | -0.34 | -0.17 |

| Region        | Meat food |       |       | Processing food |       |       | Manufacturing |       |       | Service industry |       |       |
|---------------|-----------|-------|-------|-----------------|-------|-------|---------------|-------|-------|------------------|-------|-------|
|               | QDS       | PPM   | PPD   | QDS             | PPM   | PPD   | QDS           | PPM   | PPD   | QDS              | PPM   | PPD   |
| Argentina     | 0.05      | 1.01  | 0.67  | 0.00            | 1.82  | 0.94  | 0.92          | 2.03  | 1.23  | -0.08            | 2.28  | 1.10  |
| Ukraine       | 0.00      | -0.06 | -0.05 | -0.01           | -0.08 | -0.05 | -0.03         | -0.07 | -0.05 | 0.00             | -0.07 | -0.05 |
| Russia        | 0.01      | -0.09 | -0.06 | 0.00            | -0.08 | -0.05 | 0.01          | 0.00  | -0.02 | 0.00             | -0.01 | -0.02 |
| Pakistan      | 0.00      | 0.01  | 0.00  | -0.01           | -0.03 | 0.00  | 0.02          | 0.02  | 0.01  | 0.00             | 0.04  | 0.01  |
| Kazakhstan    | 0.07      | -0.24 | -0.19 | 0.10            | 0.34  | 0.11  | 0.59          | 0.71  | 0.25  | -0.04            | 0.41  | 0.18  |
| China         | 0.00      | 0.02  | 0.01  | 0.00            | 0.04  | 0.01  | 0.01          | 0.03  | 0.02  | 0.00             | 0.05  | 0.01  |
| United States | -0.02     | 0.10  | 0.07  | 0.00            | 0.12  | 0.05  | 0.02          | 0.06  | 0.03  | 0.00             | 0.08  | 0.02  |
| Mexico        | -0.01     | -0.01 | 0.01  | 0.00            | -0.01 | 0.00  | -0.13         | -0.11 | -0.04 | 0.02             | 0.00  | -0.01 |
| Brazil        | -0.01     | 0.12  | 0.08  | -0.01           | 0.01  | 0.07  | -0.01         | 0.04  | 0.05  | 0.00             | 0.12  | 0.05  |
| South Africa  | 0.00      | 0.00  | -0.01 | -0.01           | -0.04 | -0.01 | 0.01          | 0.01  | -0.01 | 0.00             | 0.01  | -0.01 |
| Asia_I        | 0.00      | -0.03 | -0.02 | -0.03           | -0.16 | -0.05 | 0.03          | 0.03  | 0.01  | 0.00             | 0.05  | 0.01  |
| Asia_A        | 0.00      | -0.06 | -0.04 | -0.01           | -0.14 | -0.07 | 0.01          | 0.00  | 0.00  | 0.00             | 0.01  | -0.01 |
| North America | 0.00      | -0.02 | 0.00  | -0.01           | -0.03 | -0.01 | -0.09         | -0.07 | -0.03 | 0.01             | 0.01  | -0.01 |
| LaAm_I        | 0.02      | -0.45 | -0.29 | 0.00            | -1.02 | -0.43 | -0.02         | -0.11 | -0.07 | 0.02             | -0.11 | -0.08 |
| LaAm_A        | 0.05      | -0.37 | -0.25 | -0.02           | -0.46 | -0.16 | 0.13          | 0.19  | 0.11  | 0.01             | 0.25  | 0.09  |
| Europe_A      | -0.01     | -0.01 | -0.02 | -0.01           | -0.04 | -0.03 | 0.04          | -0.01 | -0.04 | -0.01            | -0.08 | -0.05 |
| EU_rest       | 0.00      | -0.05 | -0.05 | -0.02           | -0.05 | -0.03 | -0.19         | -0.22 | -0.12 | 0.01             | -0.14 | -0.08 |
| Africa_I      | 0.00      | -0.01 | -0.01 | 0.02            | 0.05  | -0.01 | 0.00          | -0.01 | -0.01 | 0.00             | 0.00  | -0.01 |
| Africa_A      | 0.00      | -0.29 | -0.16 | -0.14           | -1.12 | -0.47 | 0.14          | 0.00  | -0.05 | 0.07             | -0.04 | -0.06 |

\_I – food insecure countries; \_A – countries that are vulnerable to food security; LaAm – Latin American; EU\_rest – other European countries

Source: Authors' results are simulated by the RunGTAP 3.69 software based on the GTAP 10 database (GTAP 2019)

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Export restrictions have worsened the terms of trade (TOT) in some countries, such as Ukraine, Mexico, North America, Latin America, and African susceptible countries. In addition, it has had a negative impact on the income of residents (Y) in most countries, especially food insecure countries in Latin America and susceptible countries in Africa.

**Changes in domestic sales (QDS), prices of imported goods consumed by domestic residents (PPM), and prices of domestic goods consumed by domestic consumers (PPD).** The simulation results (Table 3) show that the price of domestic residents buying imported wheat (−3.97%) and the price of buying domestic wheat (−1.74%) have dropped significantly in Kazakhstan. At the same time, the price of imported coarse grain for domestic residents in Argentina (−1.06%) and Pakistan (−1.85%) has dropped significantly, which is obviously the result of an increase in domestic supply due to the implementation of grain export restrictions. However, the domestic consumer prices of wheat imported by Russia (4.21%) and coarse grain imported by Kazakhstan (4.87%) have both increased significantly. There are two reasons. One is that the two countries are major grain exporters, and export restrictions will directly increase the price of the world's grain market; the other is that the surge in domestic supply has promoted the increase in direct demand for food and the demand for food as an intermediate product, thereby stimulating the increase in food prices. In addition, Russia has to import some grains due to its poor climate and environment. At present, its wheat is mainly imported from Kazakhstan. The restrictions on wheat in Kazakhstan have greatly increased the price of imported grains in Russia. The double increase in market prices and import prices has prompted residents of the wheat sector in Russia. Consumer prices have risen sharply. From the perspective of supply and demand, Russia's domestic sales only increased by 0.47%, which could not offset the soaring prices caused by export restrictions in other countries.

Since grain is an indispensable intermediate product in other sectors, the impact of grain supply and price directly caused a chain reaction in other sectors. Among the countries that implement grain export restrictions, consumer prices in other sectors in Argentina have risen significantly, and grain export restrictions have seriously harmed the interests of residents.

Judging from the impact on other countries, the impact of the coarse grain sector has the greatest impact, and the coverage is the widest, and the interests of residents in many countries have been significantly

damaged; among them, the domestic sales volume of Pakistan, the United States, Brazil, and Asian food insecure countries increased slightly, and the price of imported coarse grains by residents increased significantly.

**Output effect.** Trade distortions caused by food export restrictions may affect the structure and distribution of output. Table 4 shows the impact of grain export restrictions on the output of different countries. The results show that countries that implement grain export restrictions have significantly reduced their grain output. Argentina's coarse grain output fell by 6.89%; Russia's rice output fell by 2.03%; Kazakhstan's wheat output fell by 6.92%. And wheat from food insecure countries in Asia (−1.40%), coarse grains from food insecure and susceptible countries in Latin America (−4.85%; −6.30%), and coarse grains from susceptible countries in Africa (−3.01%) have obvious negative output effects. The output changes in other sectors are not obvious.

The output of certain sectors in some regions has also increased. However, the actual conditions are difficult to achieve such a substantial increase in produc-

Table 4. Change in output effect (%)

| Region        | Wheat | Rice  | Coarse grain |
|---------------|-------|-------|--------------|
| Argentina     | −0.02 | −0.08 | −6.89        |
| Ukraine       | 0.00  | 0.00  | 0.00         |
| Russia        | 0.21  | −2.03 | −0.39        |
| Pakistan      | −0.05 | 0.00  | −0.21        |
| Kazakhstan    | −6.92 | 0.03  | −0.21        |
| China         | 0.04  | −0.01 | −0.04        |
| United States | 0.01  | 0.01  | 0.32         |
| Mexico        | 0.21  | 0.14  | 0.07         |
| Brazil        | −0.22 | 0.01  | 0.61         |
| South Africa  | 0.05  | 0.05  | 0.05         |
| Asia_I        | −1.40 | 0.01  | −0.01        |
| Asia_A        | 0.37  | 0.00  | −1.00        |
| North America | 0.00  | 0.08  | −0.04        |
| LaAm_I        | 0.54  | −0.06 | −4.85        |
| LaAm_A        | −0.18 | 0.00  | −6.30        |
| Europe_A      | 1.87  | 0.00  | 0.04         |
| EU_rest       | 0.05  | 0.41  | −0.13        |
| Africa_I      | −0.08 | 0.00  | 0.04         |
| Africa_A      | −0.15 | 0.01  | −3.01        |

\_I – food insecure countries; \_A – countries that are vulnerable to food security; LaAm – Latin American; EU\_rest – other European countries

Source: Authors' results are simulated by the RunGTAP 3.69 software based on the GTAP 10 database (GTAP 2019)

tion. Especially under the new crown epidemic, the economic downturn, the increasing political turmoil in many countries, and the large-scale impact of the locust plague have made it more difficult to increase food production in Africa. The food export restrictions of other countries have made the food security of African countries worse. If the food production cannot be increased to the level of the simulation results, these countries may have a serious food crisis.

## CONCLUSION

It can be seen that the overall supply of grain in the world exceeds demand, the implementation of grain export restrictions has caused distortions in consumption and production, harmed the interests of consumers and some farmers in the implementing countries, and led to welfare losses in some implementing countries. Some countries are suffering multiple blows from the new crown epidemic, political, economic and natural disasters, and cannot meet their own output increase. Therefore, it is difficult to achieve the new equilibrium shown by the simulation results, and grain security is seriously threatened. In short, food export restrictions may not be the best choice to solve food shortages and curb food prices under the new crown epidemic. It not only harms the interests of consumers in the implementing countries, but also distorts world market prices, spreads the impact to other countries, and even threatens some countries and regions with fragile food security, causing worldwide food panic and harming themselves and others.

To prevent these negative effects from occurring, we need to start with the rules of the measures themselves, especially to speed up the reform of WTO export restrictions related disciplines. It is necessary to elaborate and quantify the concept of WTO export restriction discipline. First, clarify the implementation boundaries of grain export restrictions, and further explain the definitions of the concepts of 'necessities', 'serious shortages' and 'temporary' in GATT Article 11, paragraph 2(a). In particular, it is necessary to make specific quantitative boundaries for 'serious shortages'. Second, it is necessary to strictly limit the scope of export tariffs to prevent some countries from raising export tariffs to achieve the purpose of restricting exports. Third, it is necessary to clarify and reduce the scope of exemptions in Article 12, paragraph 2 of the 'Agricultural Agreement', and determine the list of exemptions. Countries with a low share of the world's food market (a clear minimum threshold) and

fragile food security can be included in the exception list. In addition, strengthen the coordination between the regional cooperation mechanism and the WTO's multilateral trade mechanism in terms of export restriction discipline. However, the right to special and differential treatment and self-protection of food security 'fragile' countries in crisis situations should not be deprived. It is necessary to adhere to the unified supervision of food security based on WTO rules.

Strengthen global food security governance and jointly build a community with a shared future for mankind. Coordinate the global food supply, maintain the efficient operation of the global market, promote the matching of supply and supply capacity, and effectively transform the two to ensure that any country can buy sufficient nutritious food at a low cost.

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