The Impacts of Trade Restrictions on World Agricultural Price Volatility during the COVID-19 Pandemic

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Abstract

During the COVID-19 pandemic, countries applied trade restrictions to insulate their domestic markets from the world market. However, these trade policies could have amplified international market price fluctuations. This paper explores the effects of trade restrictions on international agricultural price volatility. A theoretical model is developed to quantify how trade policies amplify the initial shock. Using panel data covering 71 countries from January 2020 to July 2021, we examine empirically the effects of trade policies on world agricultural price volatility. The results show that trade distortions further induced volatility of world agricultural prices by around 22 percent during the COVID-19 pandemic. The multiplier effects are much more substantial in agricultural exporting countries than in importing countries. Large countries like China and the US could make significant contributions to stabilizing world prices by limiting the extent of unilateral trade policy interventions.

Keywords: agricultural price volatility, COVID-19, multiplier effect, trade restrictions

JEL codes: E30, F14, Q1

I. Introduction

The COVID-19 pandemic has been one of the greatest global health crises during the past century and has led to unprecedented challenges in global food security (Mishra and Rampal, 2020; Song and Zhou, 2020; Fan et al., 2021). During the pandemic, in
May 2021, international agricultural prices peaked, reaching their highest point since the 2008/09 spike in food prices. Agricultural prices have risen more than 20 percent since the pandemic. Moreover, world agricultural prices have displayed an increasing fluctuation trend (Figure 1). Agricultural price volatility has been a key policy concern during the past half century (Headey and Fan, 2008; Anderson, 2012; Hovhannisyan and Shanoyan, 2020). Agricultural price volatility not only represents a direct threat to global development by affecting poverty adversely (Ivanic and Martin, 2014) but also poses a sensitive political issue that could trigger social unrest (Bellemare, 2015) and political instability (Soffiantini, 2020). This is because a large proportion of international agricultural and food price shocks can be transmitted to domestic markets within a short period (Peersman, 2020). During the COVID-19 pandemic, many countries unilaterally applied trade distortions to restrict agricultural imports and exports (Mao et al., 2021). However, little is known about how COVID-19-related unilateral trade policies have amplified the volatility of world agricultural prices.

To fill this gap, we developed a theoretical model to consider the production shocks caused by the COVID-19 pandemic and the role of trade distortions. Agricultural
products are more labor intensive than manufactured goods (World Bank, 2020), so the outputs of agricultural products are more likely to be affected by the COVID-19 pandemic. Moreover, the theoretical model shows that the government’s trade distortions could amplify the volatility of world agricultural prices.

To test the theory that international agricultural prices are associated with the noncooperative trade policies of importers and exporters, monthly panel data covering 71 countries from January 2020 to January 2021 were employed to identify the effects of COVID-19-related trade policies on the volatility of the world agricultural price. This paper shows that export bans and other price-insulating policies have helped exacerbate the volatility of world agricultural prices, which is referred to as the multiplier effect. Specifically, these trade distortions have induced further volatility in world agricultural prices by around 22 percent during the COVID-19 pandemic. Our paper explores the heterogeneous effects of different types of COVID-19-related trade distortions on the volatility of world prices. We find that the multiplier effects were much more substantial in agricultural exporting countries than in importing countries.

The present paper also explores the roles of China and the US in affecting the volatility of world agricultural prices because a single country can be powerful in an uncertain world with COVID-19. This could provide a potential solution for the disarray in the international agricultural trade market. As the largest developing country in the world and the first country affected by COVID-19, China could make significant contributions to stabilizing the world agricultural market price. Thus, we further explored how China’s trade policy affects world agricultural price volatility. We found that China’s trade policy could alleviate international market price volatility. As we explored how cooperation between China and the US influenced volatility in international market prices, we empirically tested the effects of trade policies by adding in the trade policies of the US. We found that the beggar-thy-neighbor trade policies of the US increased the volatility of world prices. As major trading nations, China and the US therefore need to cooperatively open up to stabilize international market prices.

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1Only 71 countries are covered due to lack of data relating to other countries: Argentina, Armenia, Australia, Bangladesh, Belarus, Bhutan, Bolivia, Brazil, Cambodia, Cameroon, Chile, China, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Germany, Guinea, Honduras, India, Indonesia, Iran, Iraq, Israel, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lebanon, Malawi, Malaysia, Mali, Mauritania, Mexico, Morocco, Myanmar, Namibia, New Zealand, Nigeria, North Macedonia, Oman, Pakistan, Panama, Peru, Philippines, Qatar, Sudan, Romania, Samoa, Saudi Arabia, Senegal, Serbia, Seychelles, Singapore, South Africa, Sri Lanka, Switzerland, Tajikistan, Thailand, Turkey, Uganda, Ukraine, United Arab Emirates, the UK, the US, Uzbekistan, Vietnam, Zambia, and Zimbabwe.
During periods of world market price spikes, governments apply trade policies to stabilize the domestic market. Theoretically, when a food-exporting country imposes export taxes, there is an excess of domestic supply, which could lower domestic prices. If the country is a large exporter of one good, the export curbs are expected to affect the export volume, leading to a decrease in the excess supply on the world market. Conversely, a country that is a large importer would prefer to lower or remove import taxes to import more, in turn leading to excess demand on the world market. The reduction in supply and the increase in demand on the world market as a result of this disruption would obviously drive the price upwards (Martin and Anderson, 2011; Anderson and Nelgen, 2012b). An increase in the world market price could also occur when many smaller exporters apply such measures (Bouet and Laborde, 2010), and world prices will increase when many importers lower their import curbs. The resulting collective action problem has been likened to everyone standing up in a stadium to get a better view (Martin and Anderson, 2011).

In the present paper, we extended the previous literature by incorporating domestic and foreign production shocks driven by the COVID-19 pandemic into a political economy model to isolate the effect of trade interventions on world market prices. According to the findings of Estrades et al. (2017), export taxes were the most common trade policy in the agricultural sector, with more than 400 instances of export taxes during the financial crisis period from 2008 to 2014. Unfortunately, the price-insulating policies fail to stabilize domestic agricultural and food prices if the exporting and importing countries simultaneously apply trade policies (Yan and Deng, 2019), and those price-insulating policies will amplify the spikes in international agricultural and food prices (Anderson and Nelgen, 2012b; Giordani et al., 2016; Espitia et al., 2020). Our paper contributes to the literature by exploring how trade policy interventions during the COVID-19 pandemic have affected world market price fluctuations and not just regarding the absolute level of agricultural prices.

The remainder of the paper is structured as follows: Section II illustrates trade restrictions during the COVID-19 pandemic. A theoretical model is presented in Section III. Section IV describes the data, the variables, and the empirical approach. Section V discusses the empirical results. Finally, Section VI concludes the paper.

II. Trade restrictions during the COVID-19 pandemic

Many countries applied trade restrictions to insulate their domestic markets from the world market during the COVID-19 pandemic. As a result, the number of COVID-19-related trade policies increased by varying degrees. In general, the implementation of COVID-19-related trade policies has gone through roughly four stages (Figure 2).
From January to March 2020, when COVID-19 first broke out, countries began to enact and implement various trade measures. By the end of March 2020, the COVID-19 pandemic spread on a large scale. Countries such as Indonesia, the Philippines, Australia, and Thailand were in a phase of “accelerating escalation” of confirmed cases. Singapore, Italy, and Spain were in the “late accumulation” phase before the inflection point. The US and UK were in the early stages of “late accumulation.” From April to July 2020, the global pandemic continued to spread, and the number of trade measures related to the pandemic increased steadily. Beginning in July 2020, the number of trade policy implementations tended to be stable, with a small increase. By the end of December 2020, there was a smaller decline in the number of trade measures.

Global Trade Alert (GTA) classifies the trade policies related to COVID-19 into four categories, namely import curb policy, import reform policy, export curb policy, and export reform policy. Import reforms are liberalizing measures that aim to encourage imports. Import curbs are defined as restrictive import policies. Export reforms are intended to liberalize exports, and export curbs are defined as restrictive policies aiming to restrict exports.

Regarding the total number of policies implemented, countries around the world have cumulatively implemented the largest number of import reform measures since the outbreak of the pandemic, far exceeding the other three trade policies. Import reform measures related to COVID-19 increased to 30 in April 2020 and then climbed rapidly to a peak of 75 in September 2020. As the global pandemic stabilized, so too did the
number of import reform trade policies. However, by the end of 2020, the number of import reform trade policies fell sharply and then slowly declined to 53 in January 2021. The number of COVID-19-related import curbs is second only to import reforms. Since January 2020, the number of import curbs has increased steadily. By the end of January 2021, the number of import curbs had surpassed the total number of import reform measures. COVID-19-related export reform measures began to rise sharply in late March 2020. In early April, the number of export reforms exceeded the import curb measures, increased to a peak of 36, and finally decreased slowly and stabilized at 31 by January 2021. Finally, the number of export curb measures was the lowest, with changes in these measures being relatively stable. With the development of the pandemic, the number of trade policies that were implemented remained stable at around 10. After a sharp decline in December 2020, the number of all trade policies (whether import reforms or export curbs) increased further after January 2021 (as of July 2021).

With the popularization of the COVID-19 vaccines, the global pandemic was initially controlled, and the effectiveness of the trade policies adopted by countries during the COVID-19 pandemic also changed greatly. All import reforms and export curbs in eastern Europe and central Asia since January 2020 lapsed. Western Europe, north Africa, south Asia, southeast Asia, and southern Latin America retained about half of the export curb and import reform measures.

Of the retained import and export trade policies in the food sector, most policy measures have been effective for a long time (Table 1). The minimum duration of COVID-19-related trade policies was 365 days, and the number of trade policies with 1-year validity was limited, with only three export curb policies. There were nine import reforms. Among the long-term effective trade policies, import curbs and import reforms have been implemented the most often and are related to the quarantine and control measures taken by governments during the COVID-19 pandemic and to the import measures that were intended to meet domestic food demand.

|                      | Up to 30 days | Up to 90 days | Up to 365 days | More  |
|----------------------|---------------|---------------|----------------|-------|
| Export curbs         | 0             | 2             | 11             | 22    |
| Export reforms       | 3             | 3             | 6              | 4     |
| Import curbs         | 6             | 10            | 19             | 38    |
| Import reforms       | 7             | 9             | 36             | 31    |

Source: Global Trade Alert (GTA) database, August 2021 release.

Note: The duration of trade policies issued by countries in response to COVID-19 ranges from 1 month, 3 months to 9 months, and these policies were still in effect as of July 2021.
III. Theoretical model

To explore how COVID-19-related trade policies affect international market prices, a partial equilibrium model was developed based on the assumptions of Thennakoon (2015). We set the government objective function of importing and exporting countries during the periods when the world price was moving downward and when it was moving upward, respectively. Then, we theoretically analyzed the government’s noncooperative trade distortion behaviors when facing COVID-19. Finally, we solved the relationship between international agricultural prices and trade distortion.

1. Model setting

We assume that there are two countries in the world: one is an importer, and one is an exporter. The agricultural prices of the importer and exporter are denoted as $P$ and $P^*$, respectively. The demand functions of the two countries are defined as $d(P) = \alpha - P$ and $d(P^*) = \alpha - P^*$, respectively. Correspondingly, the consumer surplus functions could be presented as $CS = \int_\alpha^\alpha (\alpha - P)dp$ and $CS^* = \int_\alpha^\alpha (\alpha - P^*)dp^*$, respectively. For simplicity, the agricultural good is produced from a specific factor in the two countries, and the input–output coefficient is constant with a value of 1; $x$ and $x^*$ denote the quantity of specific factors used to produce this good in the importer and exporter countries, respectively. The return for the owners of the specific factors could be calculated by multiplying the domestic price ($P$, $P^*$) by the output ($x$, $x^*$), written as $Px$ and $P^*x^*$ for each of them. We restrict governments’ distortion policies to only trade policies. Thus, the wedge between the domestic agricultural price and the international agricultural price is presented as $P = P_w + t$ and $P^* = P_w + t^*$ for the two countries, where $P_w$ indicates the international agricultural price, $t$ and $t^*$ represent tariffs imposed by the home country and foreign country, respectively.

Domestic demand is a function of the domestic market price. However, the agricultural outputs are significantly affected by the COVID-19 pandemic because agricultural production is more labor intensive than the production of manufactured goods (World Bank, 2020). The agricultural production shocks driven by the COVID-19 pandemic are indicated as $v$ and $v^*$ for the importer and exporter, respectively.

Based on the above assumptions, the total demand for one specific agricultural product could be presented as follows:

$$D^T = d\left(P\right) + d\left(P^*\right) = (\alpha - P) + (\alpha - P^*) = [\alpha - (P_w + t)] + [\alpha - (P_w + t^*)]. \quad (1)$$

Based on the market-clearing condition, the total supply can be written as follows:

$$S^T = S + S^* = x + x^* + v + v^*. \quad (2)$$
The net import value is the difference between demand and domestic production:

\[ m = d(P) - (x + v) = \frac{1}{2}(t^* - t + x^* - x + v^* - v). \quad (3) \]

The international market price is given by the following:

\[ P^w = \alpha - \frac{1}{2}(t + t^* + x + v + x^* + v^*). \quad (4) \]

In a situation of free trade and no production shocks, world prices would be the following:

\[ P^{free} = \alpha - \frac{1}{2}(x + x^*). \quad (5) \]

Next, we discuss the trade policy choices of a government under COVID-19 and the impact of this policy on agricultural price fluctuations.

2. Government objective function

During the COVID-19 pandemic, the main objective of a government was to maintain domestic price stability. Following Thennakoon (2015) and Yan and Deng (2019), we sum the consumer surplus, producer revenue, and trade revenue (or cost) to present the total social welfare. To measure the heterogeneous political influences of consumers and producers, we also add different weights to the producer surplus (\( \gamma px \)) or consumer surplus (\( \gamma cs \)) here, following the model of Bagwell and Staiger (2011).

As discussed, agricultural product price volatility is bad for both producers and consumers. The theory, which explains the government’s motivations to apply price-insulating policies, is a political economy theory that is integrated with loss aversion theory (Freund and Ozden, 2008; Tovar, 2009). This political economy model is also widely used to analyze agricultural trade policies (Dissanayake, 2015; Thennakoon, 2015; Yan, 2016; Yan and Deng, 2019). The introduction of the loss aversion term could model why policymakers alter the trade distortion rate to partially offset deviations of the domestic market price from their trend value, as discussed by Tyers and Anderson (1992). The production shocks driven by COVID-19 (\( v \) and \( v^* \)) will have an effect on the volatility of world agricultural prices. Equation (6) presents the welfare of the importing country during a downward period in world agricultural prices:

\[ U = \gamma px P(x + v) + tm + CS - \theta \left[ \overline{P(x + v)} - P(x + v) \right], \text{ if } (\overline{P(x + v)} - P(x + v)) > \lambda px, \quad (6) \]

\[ U = P(x + v) + tm + \gamma cs CS - \theta \left( \overline{CS} - CS \right), \text{ if } (\overline{CS} - CS) > \lambda cs, \quad (7) \]

\[ U = P(x + v) + CS + tm, \text{ if } (\overline{P(x + v)} - P(x + v)) < \lambda px \text{ and } (\overline{CS} - CS) < \lambda cs. \quad (8) \]
Based on our model assumption, the first three items of Equation (6) are the producer’s revenue \(P(x+v)\), tariff revenue \(tm\), and consumer surplus \(CS\). The fourth term is the welfare weight on loss aversion. When world prices decrease, producers lose, and the government also adds weight to producers’ revenue \(\gamma px\), which is larger than 1. \(\overline{P(x+v)}\) is proposed as the reference level of the producer’s revenue. \(\overline{CS}\) is the reference of consumer surplus. \(\theta\) indicates the government’s weight on producer’s or consumer’s welfare deviating downward from the reference level. Equation (7) describes the government welfare function during an upward world price period once the loss aversion is larger than a threshold value \(\lambda cs\) and when consumers attain additional care from the government, whose weight is the same as producers during the world price downward period. \(\lambda ps\) and \(\lambda cs\) are the threshold values, and once exceeded, loss aversion takes effect from the producer and consumer sides, respectively. If the threshold values satisfy \((\overline{P(x+v)} - P(x+v)) < \lambda ps\) and \((\overline{CS} - CS) < \lambda cs\), the government’s preference function is simplified to the traditional three terms: producer revenue, consumer surplus, and the government’s tariff revenue, as shown in Equation (8).

The exporter government’s objective function is notably set to be the same as the importer government’s, and we only add * to indicate the exporter:

\[
U^* = \gamma ps P^* \left( x^* + v^* \right) - t^* e + CS^* - \theta \left[ \overline{P^* \left( x^* + v^* \right)} - P^* \left( x^* + v^* \right) \right], \\
\text{if } (\overline{P^* \left( x^* + v^* \right)} - P^* \left( x^* + v^* \right)) > \lambda ps,
\]

\[
U^* = P^* \left( x^* + v^* \right) - t^* e + CS^* - \theta \left( \overline{CS^*} - CS^* \right), \text{ if } (\overline{CS^*} - CS^*) > \lambda cs, 
\]

\[
U^* = P^* \left( x^* + v^* \right) + CS^* - t^* e, \text{ if } (\overline{P^* \left( x^* + v^* \right)} - P^* \left( x^* + v^* \right)) < \lambda ps \text{ and } (\overline{CS^*} - CS^*) < \lambda cs. 
\]

### 3. Non-cooperative trade policy

Combining loss aversion and utility maximization, governments will adopt a non-cooperative trade policy and distort world prices. It is possible to derive the international market prices when world prices increase.

For the importing country, the government would want to place more weight on producers when world prices decrease (Equation (6)). Similarly, for exporting countries, the government also considers producers more (Equation (9)). We could therefore obtain their political optimal trade policy level by taking the first-order conditions for their objective functions. In the case when the two countries do not apply cooperative trade policies, the Nash equilibrium for the two countries could be solved as in Equations (12) and (13):
The Nash equilibrium solutions show that the non-cooperative trade policies depend on the world’s total supply \((x, x^*)\), the political weights \((\gamma, \theta)\) on producers, and the loss aversion terms. The government also takes the production shocks at home and abroad, which are driven by COVID-19, into consideration when making non-cooperative trade policies.

When world prices increase, the government will care more about consumers. The Nash equilibrium solutions have the same structure as the solutions when the world prices decrease.

4. The role of trade policies in affecting world market prices

Based on the relationship between world prices and trade policies, we combine Equations (12) and (13) into Equation (4). Consequently, we can determine the final relationship between international agricultural prices and the non-cooperative trade policies of importers and exporters:

\[
P^w = P^{free} - \frac{1}{2} (\gamma + \theta - 1) (x + x^*) - \frac{1}{2} (\gamma + \theta) (v + v^*). \tag{14}
\]

When world prices decrease, trade distortions will further depress world agricultural prices (as shown by the second term in Equation (3)). World prices will also be restrained by positive production shocks, as shown by the third term in Equation (14). However, when world prices increase, government trade distortions will further push world prices upward, and negative production shocks will also increase the world’s agricultural prices.

IV. Data, variables, and identification strategy

1. Data sources and variables

The outcome variable is the volatility of agricultural prices. The monthly data (from January 2020 to July 2021) for agricultural prices come from the World Bank Commodity Price Database, which includes 17 agricultural products.\(^2\) Here, we have

\(^2\)Agriculture products include banana, barley, beef, cocoa, coconut oil, coffee arabica, copra, cotton, fishmeal, groundnut oil, groundnuts, logs, maize, meat chicken, orange, palm kernel oil, palm oil, plywood, rapeseed oil, rice, rubber, sawn wood, shrimps, sorghum, soybean meal, soybean oil, soybeans, sugar, sunflower oil, tea, tobacco, and wheat.
applied the coefficient of variation to measure agricultural price volatility (Traore and Diop, 2021). The coefficient of variation indicates that the higher the coefficient, the greater the dispersion of values around the mean. The formula is as follows:

\[
CV_t = \sigma_t = \frac{\sqrt{\sum_{t=1}^{T} (P_t - \bar{P})^2}}{\frac{T}{\bar{P}}}, \quad \text{with the price series } (t = 1,\ldots,T), \quad (15)
\]

where \( P_t \) is the price of the current period, and \( \bar{P} \) is the average price over the entire sample period. Equation (15) reflects the volatility between the current price and average price.

The variable of interest is the COVID-19-related trade policy. Data for this come from the Global Trade Alert (GTA) database, which collects information on changes in trade policy toward exports and imports of medical and food products from 75 countries documenting trade policies since the beginning of 2020. Trade policy \( (TP_{itj}) \) is defined as a dummy variable by using the time of implementation of the policy to construct monthly data. As the different trade intervention policies differ in content and intensity, we divided trade policy into four categories (import curbs, import reforms, export curbs, and export reforms) to explore the impacts of the different types of trade policies on agricultural price volatility.

We have included the COVID-19 data as a proxy for production shocks. We apply two proxy variables, including the log of the total number of confirmed cases \( (\text{cas}_i) \) and the log of the total number of people tested \( (\text{tes}_i) \). The data come from Our World in Data,\(^3\) which is updated daily and includes data on confirmed cases, deaths, hospitalizations, testing, vaccinations, and other variables of potential interest. Furthermore, the shock of COVID-19 mainly has one dimension (i.e. severity). In the econometric model, we therefore use the total monthly cases of infection and the total number of people tested in each country during the pandemic to measure the severity of COVID-19.

The other control variables are in two categories. The first are the COVID-19-related domestic policies, and the second category are macroeconomic variables that affect the price volatility of agricultural products. First, we chose the FDI \( (\text{fdi}_i) \) policy and domestic subsidy policy \( (\text{sub}_i) \). The FDI-related policy responses to the COVID-19 pandemic are an important area to monitor in the current context (Baldwin and Evenett, 2020). In recent years many countries have increasingly been using various domestic subsidy-like instruments to support domestic production and exports (Evenett, 2019). During the COVID-19 pandemic, many countries have employed domestic subsidy policy as a supplement to trade policy to achieve their political and economic goals. For the second category, trade share \( (\text{Tsha}_i) \) is the share of world trade in the affected tariff lines that

\(^3\)https://github.com/owid/covid-19-data/tree/master/public/data (cited on 10 August 2021).
have been impacted by the government’s intervention policies against pandemics; this can reflect the extent to which trade policies affect the volume of international trade during a pandemic. We also introduce GDP per capita ($gdp_{it}$), population ($pop_{it}$), price of crude oil ($oil_{it}$), price of coal ($coal_{it}$), and price of natural gas ($gas_{it}$) as additional control variables. All the variables and descriptive statistics are shown in Table 2.

Table 2. Variables and descriptive statistics

| Variable                                             | Observations | Mean  | Standard deviation | Min.  | Max.  |
|------------------------------------------------------|--------------|-------|--------------------|-------|-------|
| Outcome variable                                     |              |       |                    |       |       |
| Volatility of agricultural price ($CV_{it}$)         | 7,203        | 2.883 | 3.867              | 0.00025 | 18.84 |
| Variables of interest                                |              |       |                    |       |       |
| Trade policy (COVID-19 related) ($TP_{itj}$)         | 7,552        | 0.682 | 0.466              | 0     | 1     |
| One-month lag of trade policy ($TP_{itj-1}$)         | 7,434        | 0.683 | 0.465              | 0     | 1     |
| Export curbs policy ($TPe_{itj}$)                    | 4,384        | 0.723 | 0.448              | 0     | 1     |
| Import reforms policy ($TPi_{itj}$)                  | 2,560        | 0.775 | 0.418              | 0     | 1     |
| China’s import curbs policy ($TP_{cici_{itj}}$)      | 7,552        | 0.0127| 0.1120             | 0     | 1     |
| China’s import reform policy ($TP_{ciri_{itj}}$)     | 7,552        | 0.0297| 0.1697             | 0     | 1     |
| United States import reform policy ($TP_{air_{itj}}$)| 7,552        | 0.0127| 0.1120             | 0     | 1     |
| Main control variables                               |              |       |                    |       |       |
| Log of total number of confirmed cases ($ln cas_{it}$)| 6,784        | 10.09 | 3.584              | 0.693 | 17.08 |
| Log of total number of people tested ($ln tes_{it}$) | 4,736        | 13.32 | 2.798              | 2.639 | 19.52 |
| Other control variables                              |              |       |                    |       |       |
| FDI policy related to COVID-19 ($fdi_{it}$)          | 7,552        | 0.00847| 0.0917            | 0     | 1     |
| Domestic subsidy policy ($sub_{it}$)                  | 7,552        | 0.0763| 0.265              | 0     | 1     |
| Trade share ($Tsha_{it}$)                             | 4,512        | 0.0558| 0.127              | 0     | 0.97  |
| Log of GDP per capita ($gdp_{it}$)                    | 6,496        | 9.421 | 0.865              | 6.999 | 11.67 |
| Log of population ($pop_{it}$)                        | 6,496        | 17.75 | 1.685              | 11.50 | 21.09 |
| Price of crude oil ($oil_{it}$)                       | 7,552        | 38.24 | 10.30              | 21.04 | 61.63 |
| Price of coal ($coal_{it}$)                           | 7,552        | 64.83 | 10.52              | 56.58 | 86.85 |
| Price of natural gas ($gas_{it}$)                     | 7,552        | 1.986 | 0.342              | 1.618 | 2.663 |

2. Identification strategy

We set out to identify how much COVID-19-related trade policy contributes to the volatility in international agricultural prices. To achieve this, we developed an identification strategy based on the theoretical model shown in Equation (16). International agricultural prices are determined based on the free-trade price minus the distortions in trade policy and impact of the pandemic. We mainly discuss the effect of trade policy on world agricultural price volatility and adopt the following two-way fixed-effect model:

$$
\Delta P_{itj} = \alpha_0 + \beta_1 TP_{itj} + \alpha_i X_{itj} + \gamma_j + \lambda_i + \mu_j + e_{itj},
$$

(16)
where $\Delta P_{ij}$ is the international agricultural volatility in prices, $\alpha_0$ is a constant term, and $TP_{ij}$ is a dummy variable that represents trade policy during the pandemic (1 if there is a trade policy; 0 if there is no trade policy). $X_{ij}$ represents all other control variables, and $\gamma_i$ is the country fixed effects, which mainly capture the long-term unobserved differences between countries. $\lambda_t$ is the time fixed effect, which captures the global business cycle effect and short-term unmeasured differences. $\mu_j$ is the product fixed effect, which mainly controls the unmeasured difference overflow between different products. $e_{ijt}$ is the error term. The subscripts are $i$ for country, $t$ for time, and $j$ for product. The effect of trade policy on international agricultural price fluctuation is identified by $\beta_1$.

V. Empirical results

1. Benchmark results

Table 3 presents the benchmark estimation results by applying the ordinary least square (OLS) approach. To deal with unobserved confounders, we gradually controlled for the country-, product-, and time-fixed effects from columns (1) to (3). After the control variables were added, the coefficient stabilized at about 22.27 and was significant at the 5 percent level. The results show that trade policies in agricultural markets during the pandemic could exacerbate the volatility of world prices. The mechanism here could be that trade policy reduces the supply in the international market, and the excess demand is also increased. Hence, trade policies from importers and exporters would aggravate world agricultural price volatility.

| Variables          | (1)       | (2)       | (3)       |
|--------------------|-----------|-----------|-----------|
| $TP_{ij}$          | 27.0947***| 22.5677** | 17.1471*  |
|                    | (8.877)   | (9.726)   | (9.080)   |
| Other control variables | Yes     | Yes       | Yes       |
| Country-fixed effect | Yes     | Yes       | Yes       |
| Product-fixed effect | No      | Yes       | Yes       |
| Month-fixed effect  | No       | No        | Yes       |
| Observations       | 2,611    | 2,611     | 2,611     |

Notes: ***, **, and * represent significance at the 1, 5, and 10 percent levels, respectively. The variable of interest is trade policy related to COVID-19 ($TP_{ij}$). For other control variables, see the definition in Table 2. The robust standard errors are presented within parentheses.

2. Endogeneity concerns

There may be some potential endogeneity issues because trade policy could also be affected by the number of confirmed cases and the number of people tested. A two-
stage least square (2SLS) approach is applied to address this concern. The number of confirmed cases and people tested are used as instruments of trade policy. The first stage is to test the effects of instrument variables (the number of confirmed cases and people tested) on trade policy, and the second stage is to examine how trade policy affects world agricultural price volatility. The number of confirmed cases and people tested satisfy the exclusion restriction to be employed as instrument variables.

Table 4 presents the 2SLS estimates of the causal effect of trade policy on world price volatility. Columns (1) and (2) employ either the total number of confirmed cases or people tested as a single instrument for trade policy. Column (3) combines the two variables as an instrument for trade policy. The purpose of exploring these three different regression specifications is to investigate whether the 2SLS estimates are robust or not. The results from the 2SLS estimation show that the effect of trade policy on international agricultural price volatility is statistically significant, and the magnitude of the coefficient remains the same as the results estimated by applying the OLS estimation shown in Table 3.

| Variables | (1)         | (2)         | (3)         |
|-----------|-------------|-------------|-------------|
| $TP_{itj}$| 22.1047***  | 22.5317**   | 23.1471***  |
|           | (6.677)     | (8.726)     | (9.080)     |
| First stage: |            |             |             |
| $\ln\text{cas}_{it}$ | 12.1732***  | 10.9216***  |             |
|           | (3.897)     | (3.338)     |             |
| $\ln\text{tes}_{it}$ | 12.8402***  | 7.5840**    |             |
|           | (3.456)     | (3.843)     |             |
| First-stage $F$ statistics | 11          | 14          | 21          |
| Other control variables | Yes         | Yes         | Yes         |
| Country-fixed effect | Yes         | Yes         | Yes         |
| Product-fixed effect | Yes         | Yes         | Yes         |
| Month-fixed effect | Yes         | Yes         | Yes         |
| Observations | 2,611       | 2,611       | 2,611       |

Notes: *** and ** represent significance at the 1 and 5 percent levels, respectively. The variable of interest is trade policy related to COVID-19 ($TP_{itj}$). The number of confirmed cases ($\ln\text{cas}_{it}$) and people tested ($\ln\text{tes}_{it}$) satisfy the exclusion restriction to be employed as instrument variables. For other control variables, see the definition in Table 2. The robust standard errors are presented within parentheses.

3. Robustness checks

Since the beginning of 2021, a number of trade policies have been used frequently, and world price volatility has shown an upward trend. As an additional robustness check, we updated the data to July 2021. Table 5 presents the estimation results for the different
periods. Column (1) shows the impact of trade policies during COVID-19 on agricultural price volatility between January 2020 and January 2021, with trade policies accounting for about 23 percent of the volatility in agricultural prices. Column (2) presents the effect of trade policies on price volatility from January to July 2021. According to the GTA database (August 2021 release), the number of trade policies with export curbs and import reforms has further increased, and the effect of the changes in trade policies on the price fluctuation of agricultural products remains at about 22 percent.

Table 5. Two-stage least-square estimation results for different periods

| Variables | Price volatility |
|-----------|------------------|
|           | (1) Jan. 2020–Jan. 2021 | (2) Jan. 2021–Jul. 2021 |
| $TP_{itj}$ | 23.1471** (9.080) | 22.3346** (9.726) |
| First stage: | | |
| $\ln cas_{it}$ | 10.9216*** (3.338) | 12.9216*** (3.218) |
| $\ln tes_{it}$ | 7.5840** (3.843) | 6.5120** (3.233) |
| First-stage $F$ statistics | 21 | 17 |
| Other control variables | Yes | Yes |
| Country-fixed effect | Yes | Yes |
| Product-fixed effect | Yes | Yes |
| Month-fixed effect | Yes | Yes |
| Observations | 2,611 | 1,211 |

Notes: *** and ** represent significance at the 1 and 5 percent levels, respectively. The variable of interest is trade policy related to COVID-19 ($TP_{itj}$). The number of confirmed cases ($\ln cas_{it}$) and people tested ($\ln tes_{it}$) satisfy the exclusion restriction to be employed as instrument variables. For other control variables, see the definition in Table 2. The robust standard errors are presented within parentheses.

Table 6 presents the impacts of different types of trade policies in importing and exporting countries on agricultural price volatility. When facing adverse agricultural price shocks, governments tend to be concerned about politically sensitive issues (such as unemployment) and often raise the number of trade restrictions to insulate the domestic market from the international market. Simultaneous trade interventions from the exporting countries and importing countries exacerbate these price increases and the international welfare transfers related to changes in international food prices (Anderson and Nelgen, 2012a; Aragi et al., 2020; Evenett, 2020). Thus, we chose import reforms and export curbs as the policy reflection of the importing and exporting countries, respectively. Columns (1) and (2) present the effects of trade policy on international agricultural price volatility in the exporting countries. Columns (3) and (4) present the effect of trade policy on international agricultural price volatility in the importing countries. In the exporting
countries, a one-unit increase in export curbs elevates the international agricultural price volatility by 19 percent, while the coefficient in importing countries is 15 percent. The trade policy effects of the importing and exporting countries are obviously asymmetrical. Trade policies from the exporting countries have larger effects on agricultural price volatility. According to previous research (Anderson and Thennakoon, 2015), adopting export bans only provides temporary advantages due to soaring international food prices. Therefore, governments should abolish such noncooperative trade interventions (Martin and Anderson, 2011; Anderson and Nelgen, 2012a).

### Table 6. Export curbs, import reforms, and world price volatility

| Variables | Export countries | Import countries |
|-----------|------------------|------------------|
|           | (1)              | (2)              | (3)              | (4)              |
| $TP_{ec_{ij}}$ | $13.4371^{***}$ | $19.4253^{***}$ | $12.8281^{***}$ | $15.5687^{***}$ |
|           | (0.010)          | (0.026)          | (0.004)          | (0.023)          |
| $TP_{ir_{ij}}$ |                  |                  |                  |                  |
|           |                  |                  |                  |                  |
| First stage: |                  |                  |                  |                  |
| $ln\ cas_{it}$ | $0.2128^{***}$  | $0.0717^{***}$  | $0.0717^{***}$  | $0.0754$       |
|           | (0.046)          | (0.007)          | (0.110)          | (0.110)         |
| $ln\ tes_{it}$ | $8.6817^*$      | $0.0754$       |                  |                  |
|           | (0.742)          | (0.0754)        |                  |                  |
| First-stage $F$ statistics | 11              | 14              |                  |                  |
| Other control variables | Yes         | Yes         | Yes         | Yes         |
| Country-fixed effect | Yes          | Yes          | Yes          | Yes          |
| Product-fixed effect | Yes          | Yes          | Yes          | Yes          |
| Month-fixed effect | Yes          | Yes          | Yes          | Yes          |
| Observations | 2,433        | 832         | 4,137        | 1,594        |

Notes: *** and * represent significance at the 1 and 10 percent levels, respectively. The variables of interest are export curb policy ($TP_{ec_{ij}}$) and import reform policy related to COVID-19 ($TP_{ir_{ij}}$). The number of confirmed cases ($ln\ cas_{it}$) and people tested ($ln\ tes_{it}$) satisfy the exclusion restriction to be employed as instrument variables. For other control variables, see the definition in Table 2. The robust standard errors are presented within parentheses.

The results from the above robustness checks further confirm a positive and significant effect of COVID–19-induced trade policy on the volatility of world agricultural prices.

### 4. The role of China

As the first country to discover and control COVID–19, China has used different methods for controlling the pandemic. China has also made great contributions by limiting the extent of unilateral trade policy interventions to global price stability. On 22 April 2020, there was an announcement by 50 governments, including China and the US, that they would maintain open and predictable trade in agricultural and food products. The
signatories pledged not to impose export curbs on agricultural products (Baldwin and Evenett, 2020). Moreover, China’s trade policies during the COVID-19 pandemic were all import policies (see the GTA database). We therefore explore the effects of China’s import policies on agricultural price volatility. The results from columns (1) and (2) in Table 7 show that China’s import curbs could stabilize world agricultural prices. China has restricted imports to control the pandemic, which has considerably reduced domestic demand. China has also adopted a strict policy at home, with the government calling for fewer outdoor activities and fewer trips to shopping locations, and less travel in general, which has somewhat dampened domestic demand. Consequently, it has made a significant contribution to stabilizing international prices (Yu, 2020).

Table 7. COVID-19-induced trade policy and world price volatility (China and the US)

| Variables       | Price volatility | Price volatility | Price volatility | Price volatility |
|-----------------|------------------|------------------|------------------|------------------|
| $TP_{cir_{itj}}$ | 0.0146***        | 0.03187***       | 0.00717***       | 0.0314**         |
|                 | (0.002)          | (0.001)          | (0.006)          | (0.010)          |
| $TP_{cic_{itj}}$ | −1.5953***       | −1.5754***       | 3.0421***        | 3.2748*          |
|                 | (0.004)          | (0.023)          | (0.003)          | (2.008)          |
| $TP_{air_{itj}}$ |                  |                  |                  |                  |
| First stage:    |                  |                  |                  |                  |
| ln cas$_{it}$   | 0.5023***        | 0.0717***        |                  |                  |
|                 | (0.006)          | (0.001)          |                  |                  |
| ln tes$_{it}$   | 0.0817*          | 0.0314**         |                  |                  |
|                 | (0.072)          | (0.010)          |                  |                  |
| First-stage $F$ statistics | 11 | 14 |
| Other control variables | Yes | Yes | Yes | Yes |
| Country-fixed effect | Yes | Yes | Yes | Yes |
| Product-fixed effect | Yes | Yes | Yes | Yes |
| Month-fixed effect | Yes | Yes | Yes | Yes |
| Observations    | 7,086            | 2,832            | 7,086            | 1,594            |

Notes: ***, **, and * represent significance at the 1, 5, and 10 percent levels, respectively. The variables of interest are China’s import reform policy ($TP_{cir_{itj}}$), China’s import curbs policy ($TP_{cic_{itj}}$), and the US import reform policy ($TP_{air_{itj}}$). The number of confirmed cases (ln cas$_{it}$) and people tested (ln tes$_{it}$) satisfy the exclusion restriction to be employed as instrument variables. For other control variables, see the definition in Table 2. The robust standard errors are presented within parentheses.

Columns (3) and (4) in Table 7 show the effects of US trade policy on global agricultural price volatility, mainly in terms of import trade policies (see the GTA database). The US import reform policies led to further world agricultural price volatility by approximately 3 percent.

By comparing the effects of trade policies taken by China and the US, as shown in Table 7, we can see that China and the US mainly adopt import measures in which the import distortions will aggravate market volatility. However, China’s import curb policy is
conducive to the stability of international agricultural product market prices. Trade policy cooperation could be a feasible way for countries to stabilize world agricultural prices.

VI. Conclusion

The volatility of agricultural prices during the COVID-19 pandemic induced unprecedented food security issues, making agricultural prices a research hotspot. Agricultural price volatility is considerably more important than price spikes. To stabilize domestic agricultural prices, countries have applied a “beggar-thy-neighbor” agricultural trade policy to insulate the domestic market from the international market. However, little is known about how COVID-19-related unilateral trade policies would amplify the volatility of world agricultural prices. The present paper was intended to fill this gap.

A theoretical model was developed by incorporating COVID-19 production shocks in a political economy framework. The theoretical model predicted that world agricultural prices would be distorted by trade policies. We also tested the theoretical predictions by adopting large monthly panel data covering 71 countries between January 2020 and January 2021. The results confirmed the theoretical predictions, showing that these trade distortions led to further volatility of world agricultural prices by around 22 percent during the COVID-19 pandemic. However, the multiplier effects were much more substantial in agricultural exporting countries than in importing countries. This suggests that export bans, along with other price-insulating policies, helped exacerbate the volatility of world agricultural prices.

As the world’s largest developing country, China could contribute substantially to stabilizing the world agricultural market. Thus, we separated China’s trade policy to explore how China’s trade policy affects the volatility of world agricultural prices. The results show that China’s trade policy could alleviate volatility in international market prices. United States’ trade policy was also found to have added to the volatility in international market prices. China, the EU, and the US are the world’s largest traders. They have a big stake in a multilateral and bilateral system of rules (Hoekman and Wolfe, 2021). The relationship between the US and China is strained at the moment. The COVID-19 pandemic has had a severe impact on the world economy. From the perspective of economic recovery, China and the US should make cooperative trade policies to stabilize international agricultural prices.

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