

FEATURED ARTICLE

The impact of COVID-19 trade measures on agricultural and food trade

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Abstract

This paper assesses the determinants of temporary non-tariff measures (NTMs) in response to COVID-19 and their implications for the agricultural and food trade. Using a control function approach, we show that economic and pandemic considerations played an essential role in implementing such NTMs. Relying on variation between treated and untreated varieties, we estimate a dynamic post-event trade response of 5.4% for import facilitating and -27.5% for export restricting NTMs. After revoking them, their trade effects fade away, implying that these temporary trade policies were effective in achieving the set policy goals, causing only a limited degree of long-term trade disruptions.

KEYWORDS

Agricultural and food trade, COVID-19, non-tariff measures, dynamic treatment effects, policy determinants

JEL CLASSIFICATION

F13, Q17

The agricultural and food sector is highly integrated into the global economy (Lim, 2021; Yi et al., 2021). Although trade frictions between countries have been lowered by eliminating tariffs through multilateral and regional integration, this shift coincided with the growing use of various new trade measures (Santeramo & Lamonaca, 2019). Among them, non-tariff measures (NTMs) are of particular concern for their potentially adverse trade effects (Curzi et al., 2020). NTMs are defined as trade policies that can have an economic effect on international trade (Hoekman & Nicita, 2011). Among others, trade restricting NTMs include

quotas, embargoes, sanctions, and levies (Beckman & Arita, 2017; Gruère & Brooks, 2021). In contrast, trade facilitating NTMs are put in place to promote the exchange of goods across international borders (Ahn & Steinbach, 2021). Amid the ongoing debate over the role of NTMs, the pandemic has been used by various countries to justify the use of additional NTMs (Chen & Mao, 2020). The rapid increase in COVID-19 cases resulted in a growing demand for certain products directly related to human health and disease prevention, prompting several governments to secure priority access to these products by imposing import facilitating or export restricting NTMs (World Trade Organization, 2020). These COVID-19 related NTMs are distinct from the more traditional NTMs. They were imposed temporarily in response to the public health crisis and fears about supply chain bottlenecks, targeting various agricultural and food products (Ker & Cardwell, 2021).

A substantial literature assesses the diverse trade effects of NTMs, paying particular attention to the NTM type and both industry and regional differences (e.g., Curzi et al., 2020; Disdier et al., 2008; Peterson et al., 2013). These studies reveal substantial heterogeneity in the trade response to NTMs. For example, Curzi et al. (2020) find that the most restrictive standards raised as specific trade concerns negatively affect firm-level trade margins, while sanitary and phytosanitary (SPS) and technical barriers to trade (TBT) can have positive effects on such margins. Peterson et al. (2013) find that SPS measures reduce trade, but the negative impact diminishes as exporters adapt to the new trading standards. According to Disdier et al. (2008), SPS and TBT significantly reduce exports from developing to developed countries, revealing considerable treatment heterogeneity.

The coronavirus pandemic acted as a trade impediment because governments implemented public health and trade policies to combat the disease (Evenett et al., 2022). In response to the disease outbreak, global agricultural and food trade fell by 5% to 10% in 2020 compared to the past 4 years while the estimated trade effects are more substantial for the non-agricultural sector (Arita et al., 2022). Even for countries part of the same trading block, the overall trade decreased by 5% (Barbero & José de Lucio, 2021). Several studies analyzed the drivers of these temporary trade measures. Gruère and Brooks (2021) find strong justification for COVID-19 related NTMs implemented in the first quarter of 2020, pointing toward their potential to cause market disruptions. Lee and Prabhakar (2021) discuss implications for Sustainable Development Goals, while Ahn and Steinbach (2021) examine the determinants of COVID-19 NTMs. Focusing on NTMs implemented in Spring 2020, their results show that countries reacted to COVID-19 case numbers when implementing trade facilitating or restricting NTMs.

This paper assesses the determinants and trade effects of NTMs targeting the agricultural and food sector imposed in response to COVID-19. We compiled a dataset on COVID-19 related temporary trade measures and linked it to monthly trade flows at the level of the harmonized system (HS) subheading (six digits). Our identification strategy relies on variation between treated and untreated *varieties* (product-country pairs), which allows us to tease out the treatment effects of COVID-19 related NTMs. First, we used a control function approach to investigate the determinants of COVID-19 related NTMs. Our results show that higher domestic COVID-19 case numbers reduce the probability of a country implementing an import facilitating NTM against a specific *variety*. In contrast, an elevated foreign COVID-19 prevalence has a statistically significant impact on import facilitating NTMs. We also find that a higher domestic COVID-19 prevalence correlates positively with export restricting NTMs, while the opposite effect holds for foreign COVID-19 case numbers. Second, we used a gravity-type regression specification paired with high-dimensional fixed

effects to assess the trade effects of COVID-19 related NTMs for the agricultural and food sector. Our results for the static regression model show that import facilitating NTMs caused an average post-event increase of 4.7% in trade volume. We find a 5.7% reduction in trade volume for export restricting NTMs. Both trade effects are insignificant at conventional levels of statistical significance. After accounting for treatment dynamics over time, we find evidence that the trade effects are most substantial within the first 5 months after implementing a temporary trade measure, resulting in average post-event trade effects of 5.4% for import facilitating NTMs and -27.5% for export restricting NTMs. These estimates hold up to a battery of robustness checks and point toward the presence of treatment dynamics that the traditional static regression approach for assessing NTMs cannot address. The dynamic trade effects of import facilitating and export restricting NTMs fade away after the revocation of these temporary trade measures, implying that they effectively achieved the set policy goals and caused no long-term trade disruptions.

The paper provides three distinct contributions to the growing literature on NTMs and the trade effects of the coronavirus pandemic. First, we are the first to assess the impact of COVID-19 related import facilitating and export restricting NTMs on agricultural and food trade using a credible causal inference design that relies on variation between treated and untreated *varieties* (product-country pairs). Earlier studies concerned with the trade effects of COVID-19 have overlooked the differential impacts caused by these temporary trade measures (Arita et al., 2022; Evenett et al., 2022; Lee & Prabhakar, 2021). Our paper is the first to show that export restricting NTMs played an essential role in shaping trade patterns of targeted *varieties*. Furthermore, we prove that export restricting NTMs achieved the set policy goals while we are finding no evidence of long-term trade disruptions. These results indicate that temporary trade measures are a driver of agricultural trade costs (Beghin & Schweizer, 2021). Second, we contribute to the empirical literature on temporary trade policies. All related studies rely on static regression models to assess their trade implications (e.g., Hoekman et al., 2022; Santeramo & Lamonaca, 2019). However, as we show in this paper, it is essential to consider the treatment dynamics caused by NTMs. We show that the static approach is incapable of accounting for the observed dynamic treatment paths, resulting in estimation bias in the presence of significant pre-trends (Rambachan & Roth, 2019; Sun & Abraham, 2021). Third, we provide a nuanced discussion on trade facilitating and restricting NTMs. Most studies concerned with these temporary trade policies focus on their role in hampering international trade (Koppenberg et al., 2021; Mallory, 2021). Our paper is the first to document differential trade effects for import facilitating and export restricting NTMs. The average post-event trade effects are insignificant for import facilitating but highly significant for export restricting NTMs, pointing toward the fact that a temporary trade barrier can be highly beneficial in times of public emergencies to achieve trade policy goals.

COVID-19 RELATED NTMS

Since the COVID-19 pandemic started in 2020, 58 countries and one economic block implemented COVID-19 related NTMs in the agricultural and food sector. As early as February 2020, countries took action to promote or reduce agricultural and food trade. This number surged in March and April 2020, when about 20 NTMs were imposed each month.

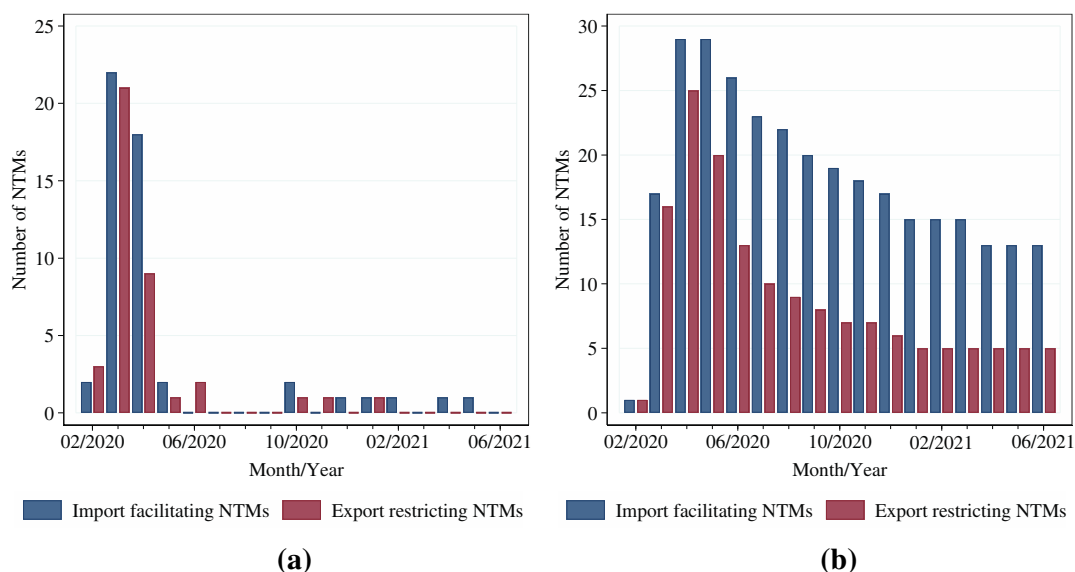


FIGURE 1 COVID-19 related non-tariff measures (NTMs) in the agricultural and food sector. (a) Newly enforced NTMs. (b) Number of NTMs in force. *Note:* The figure shows the timeline of globally newly enforced and in-force COVID-19 related NTMs from February 2020 to June 2021. Blue indicates import facilitating NTMs and red indicates export restricting NTMs. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Figure 1 provides an overview of import facilitating and export restricting NTMs implemented in response to the COVID-19 pandemic. It is shown in Figure 1a that NTM implementation clustered around March and April 2020, while Figure 1b indicates that most policies were revoked after 5 months. We show countries that implemented NTMs in Figure 2a,b. The countries that used import facilitating NTMs tend to be less developed and characterized by low levels of food security. This pattern is also observable for export restricting NTMs. Considering the number of NTMs by product group, we find that the most frequently targeted product is ethyl alcohol (HS 2207.10), which is used for medical preparations to prevent the spread of COVID-19, as shown in Figure 2c,d. A critical driver of this pattern is that most countries were not equipped with the necessary medical supplies and preparations when the pandemic started. Therefore, countries such as Brazil, Kazakhstan, and Taiwan implemented NTMs on such products in February 2020, aiming to secure access by imposing import facilitating or export restricting NTMs. In addition to ethyl alcohol, trade measures have been taken on staple food such as grains, vegetables, and dairy products.

Table 1 lists targeted agricultural and food products and the corresponding reporting countries of COVID-19 NTMs. Overall, we find that these NTMs targeted about 1.2% of global agricultural and food exports (\$15.8 billion) and 0.6% of global agricultural and food imports (\$7.7 billion), measured in 2019 values. Bolivia, Colombia, El Salvador, and Switzerland imposed NTMs on staple crops and dairy products, such as wheat, maize, rice, milk, and eggs, to facilitate imports. According to the World Food Programme (2022), Bolivia, Colombia, and El Salvador have been particularly concerned about food security. Therefore, the measures they have aimed to stabilize the domestic food supply. This pattern

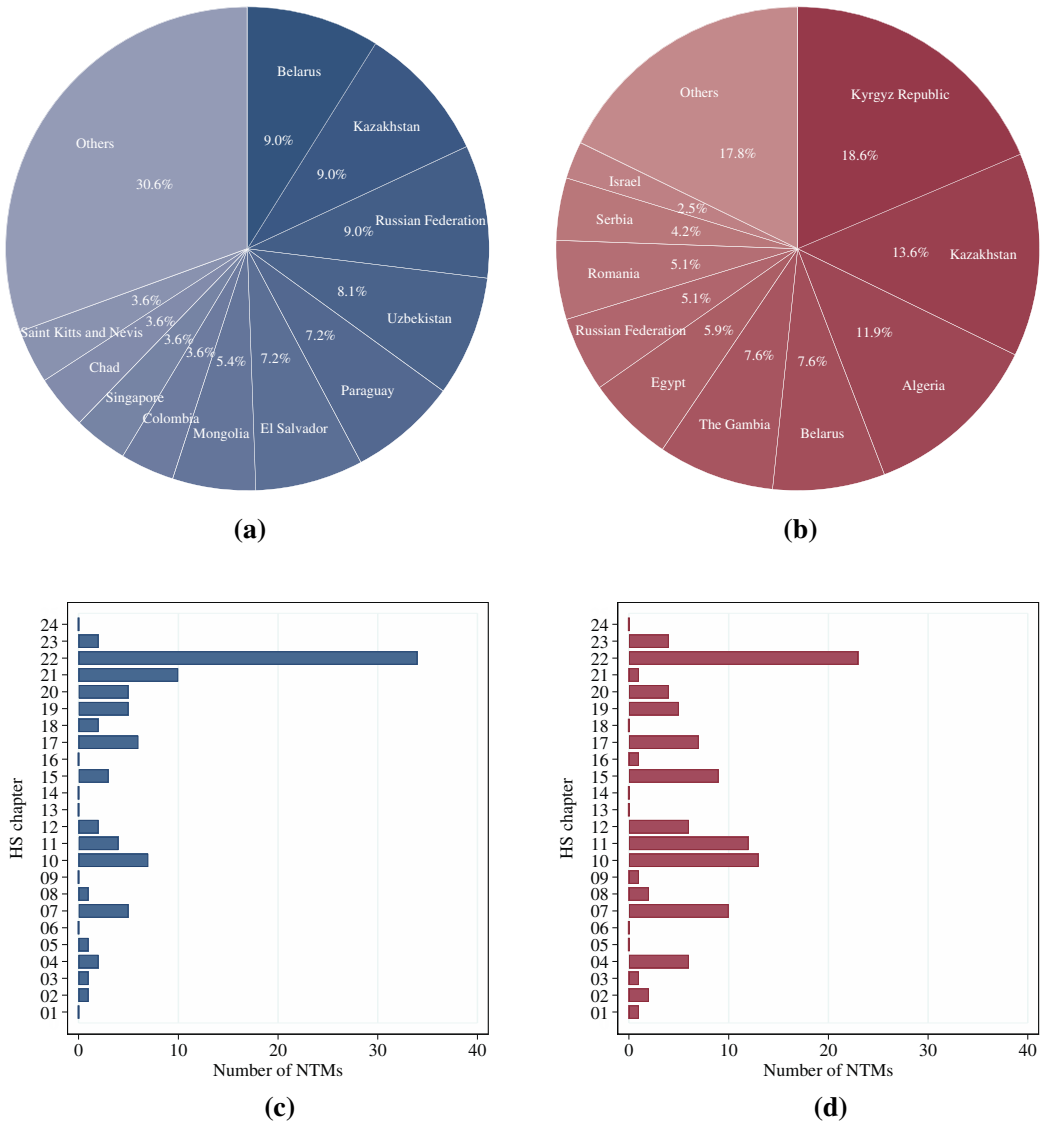


FIGURE 2 Implementing countries of COVID-19 related non-tariff measures (NTMs) and targeted HS chapters. (a) Import facilitating NTMs by country. (b) Export restricting NTMs by country. (c) Import facilitating NTMs by HS chapter. (d) Export restricting NTMs by HS chapter. *Note:* The figure shows COVID-19 related NTM implementing countries and targeted HS chapters in the agricultural and food sector. Blue indicates import facilitating NTMs and red indicates export restricting NTMs. [Color figure can be viewed at wileyonlinelibrary.com]

also applies to agricultural and food products targeted by export restricting NTMs. Most countries restricted exports of staple crops, such as wheat, buckwheat, maize, barley, and sunflower seeds. Thailand and Turkey were exceptional as they also decided to put restrictions on eggs and citrus fruits, indicating that COVID-19 NTMs were primarily enforced to ensure a sufficient domestic food supply.

TABLE 1 Food products targeted by COVID-19 related non-tariff measures

Reporting country	Targeted food products	
	Import facilitating NTMs	Export restricting NTMs
Belarus		Buckwheat, cereal grains, onions and shallots, garlic, etc. (\$34.1 million)
Bolivia	Wheat, etc. (\$17.0 million)	
Colombia	Maize, grain sorghum, soybeans, etc. (\$2.1 billion)	
El Salvador	Milk and cream, kidney beans, maize, rice, wheat, maize flour, etc. (\$0.4 billion)	Kidney beans, etc. (\$1.1 million)
Kazakhstan		Buckwheat, cane or beet sugar, potatoes, sunflower seeds, wheat, etc. (\$1.3 billion)
Romania		Wheat, barley, oats, maize, rice, soybeans, sunflower seeds, etc. (\$4.1 billion)
Russian Federation		Wheat, rye, barely, maize, etc. (\$7.7 billion)
Serbia		Sunflower seeds, maize, etc. (\$0.6 billion)
Switzerland	Milk and cream, butter, eggs, etc. (\$44.6 million)	
TFYR of Macedonia		Wheat, etc. (\$1.1 million)
Thailand		Eggs, etc. (\$21.6 million)
Turkey		Citrus fruits, etc. (\$0.2 billion)

Note: The table listed selected edible food products targeted by import restricting and export facilitating NTMs. We report the 2019 trade values of targeted *varieties* in parenthesis.

METHODS AND DATA

COVID-19 related NTM determinants

We use a linear regression model to identify the determinants of COVID-19 related NTMs. The baseline specification includes economic and pandemic-related measures as covariates. The pandemic progression is a potential driver of COVID-19 related trade actions (Barbero & José de Lucio, 2021; Barlow et al., 2021). However, unobserved confounders are potentially causing measurement errors in the domestic and foreign COVID-19 case numbers (Karabulut et al., 2021). Because the time-invariant product-year and time-fixed effects cannot adequately address the endogeneity concern, we account for this source of time-variant endogeneity bias by modeling the endogeneity in the error term via control functions (Heckman & Robb Jr, 1985). We deploy the two-stage approach popularized by Terza et al. (2008) and include the first-stage residuals as additional regressors in the second-stage regressions. The approach requires fewer assumptions than maximum likelihood and is computationally straightforward, an essential feature for a dataset with high-dimensional fixed effects (Wooldridge, 2015). The second stage regression takes the following generalized form:

$$NTM_{ikt} = \beta_E E_{ikt} + \beta_C C_{it} + \beta_R R_{ikt} + \alpha_{ik} + \gamma_t + \varepsilon_{ikt}, \quad (1)$$

where we denote the country with i , the product with k , and the time with t . The model controls for the influence of unobserved factors that could confound the relationship of primary interest with product-country α_{ik} and time γ_t fixed effects. The specification resembles the classical two-way fixed effects regression (Wooldridge, 2010).¹ The dependent variable NTM_{ikt} takes the value one if a *variety* (product-country pair) is treated with an NTM. We distinguish between import and export facilitating and restricting NTMs. Note that there are only a few import restricting and export facilitating NTMs, prompting us to be cautious about the interpretation of these parameter estimates. The set of economic explanatory variables E_{ikt} includes the applied tariff level, the 12-month lagged trade values, the one-month lagged exchange rate, and the 12-month lagged food security level. We use the lagged domestic and foreign positive COVID-19 cases C_{it} as the primary variables of interest, as we aim to understand how COVID-19 case numbers shaped the decision of policymakers to implement COVID-19 related NTMs.

As we are concerned about the potential endogeneity of the reported COVID-19 cases, which is a particular concern at the beginning of the pandemic (Lau et al., 2020), we use three instruments to account for this source of measurement error. We include the income per capita, the agricultural employment rate, and the agricultural GDP as instrumental variables in the first stage regression. The income per capita correlates strongly with the testing and vaccine capabilities of a country (Nhamo et al., 2021), while the agricultural employment rate and the agricultural GDP account for the development stage and access to healthcare services, which are critical drivers of reported COVID-19 case numbers (Kilani & Georgiou, 2021). They are uncorrelated with the probability of a country implementing a COVID-19 related NTM against a particular product but strongly correlated with COVID-19 case count. We use the predicted residuals R_{ikt} in the second stage regression to control for the measurement bias caused by misreported COVID-19 case numbers. Because the second-stage errors are asymptotically biased, we bootstrapped them by replacing them within product-country pairs for 1000 replications.

Trade effects

We use a gravity-type regression specification to assess the impact of COVID-19 related NTMs on agricultural and food trade. The identification strategy builds on Grant et al. (2021) and Arita et al. (2022), who used a similar research design and a static regression model to investigate the trade effects of the 2018 China-U.S. trade war and the coronavirus pandemic. The baseline model is specified as follows:

$$\log(y_{ikt}) = \beta_1 NTM_f_{ikt} + \beta_2 NTM_r_{ikt} + \alpha_{ik} + \gamma_{it} + \delta_{kt} + \varepsilon_{ikt}, \quad (2)$$

where we denote the country with i , the product with k , and the time with t . The outcome variable is denoted by y_{ikt} . We investigate the impact of COVID-19 related NTMs on the import and export value, quantity, and unit value. The model controls for the influence of unobserved factors that confound the relationship of primary interest with product-country α_{ik} , country-time γ_{it} , and product-time δ_{kt} fixed effects. We allow the country and product fixed effects to be flexible over time because multiple unobserved factors are likely to determine product demand and supply. An advantage of this specification is that it accounts for shocks resulting from

unobserved changes in the demand and supply patterns for agricultural and food products. For instance, the demand for ethyl alcohol is strongly driven by domestic demand and supply factors unobserved during the COVID-19 pandemic. The same holds for restrictions on grain exports, as they were imposed by the Russian Federation in April 2020. Therefore, by allowing the fixed effects to be flexible over time, we can account for these unobserved shocks and threats to our identification strategy. We address level differences between products and countries through the product-country fixed effects. We denote the additive error term by ε_{ikt} . The terms $\beta_1NTM_f_{ikt}$ and $\beta_2NTM_r_{ikt}$ measure the treatment effects of COVID-19 related NTMs on agricultural and food trade. We estimate the trade effects of facilitating and restricting NTMs jointly. The baseline model is static, that is, we assume that the treatment effects do not vary before and after the policy change.² The identification strategy relies on variation between treated and untreated *varieties* (product-country pairs) over time, building on earlier work by Carter and Steinbach (2020), Fajgelbaum et al. (2020), and Flaaen et al. (2020). Our approach builds on the parsimonious assumption that all latent confounders are invariant at the product-country level and are thus captured by α_{ik} , or are time-variant at the product and country level and are thus captured by γ_{it} and δ_{kt} . We log-transformed the outcome and rely on a heteroskedasticity-robust version of the log-linear estimator to identify the parameters of interest (Wooldridge, 2010). We account for the high-dimensional fixed effects by using a modified version of the iteratively re-weighted least-squares (IRLS) algorithm robust to statistical separation and convergence issues (Correia et al., 2019). Following standard practice in the international economics literature, we assume the standard errors to be correlated at the product-country level, prompting us to cluster them at this level (Cameron & Miller, 2015; Weidner & Zylkin, 2021).

Data

Data on COVID-19 related NTMs come from the WTO's NTM database (World Trade Organization, 2021). The WTO has collected such data from member countries going back to January 2020. We classify them according to their purpose into trade restricting and facilitating NTMs and distinguish between export and import policies. Note that all NTMs are discriminatory at the *variety* level. Fifty-eight countries implemented COVID-19 related NTMs in the agricultural and food sector. These policies targeted products listed under 100 different HS subheadings. Overall, we find that 1177 *varieties* were targeted by these temporary trade policies, equaling a treatment frequency of about 2%. We obtained monthly agricultural import data at the Harmonized System (HS) subheading level (HS6) for 88 countries from January 2019 to June 2021 from the Global Trade Atlas (IHS Markit, 2021). Data on COVID-19 positive cases comes from the Center for Systems Science and Engineering at Johns Hopkins University (Dong et al., 2020). Based on their database, we generate the number of monthly domestic and foreign positive cases for each country. Applied tariff rates at the HS 6-digit product level were derived from the Tariff Analysis Online (World Bank, 2021a). We obtained the monthly exchange rates for each national currency per US-\$ from the International Financial Statistics (International Monetary Fund, 2021). We calculated the first lag for the exchange rate and monthly COVID-19 cases. Data on the food security level comes from FAOSTAT (Food and Agriculture Organization, 2021). We used the 12-months lagged average dietary energy supply adequacy as a proxy for food security. GDP per capita, agricultural employment rate, and agricultural GDP come from the World Development Indicators (World Bank, 2021b). We

converted the food security level, GDP per capita, agricultural employment rate, and agricultural GDP into 12-months lagged weighted variables to match them with the outcome. Finally, we used GDP per capita, agricultural employment rates, and agricultural GDP as instruments to account for the endogeneity of monthly COVID-19 cases. Our final balanced dataset covers 87 countries and 920 agricultural and food products at the HS subheading level for January 2019 to June 2021.³ We provide the descriptive statistics in Table S1.

RESULTS AND DISCUSSION

COVID-19 related NTM determinants

We report the control function estimates for the determinants of COVID-19 related NTMs in Table 2. The second stage shown in Table 2a, and Table 2b shows the first stage estimates. The first stage instrumental variables are highly relevant, as shown in Panel (b). The regressions explain a significant share of the observed variation, as indicated by the adjusted R^2 . The Kleibergen–Paap F statistics prove that the instrumental variables are relevant. Focusing on Table 2b, we find that the first stage residuals are significant for import facilitating and export restricting NTMs but not for import restricting and export facilitating NTMs. This limited statistical power for the import restricting and export facilitating policies results from the low number of NTMs implemented to restrict imports and facilitate exports of agricultural and food products. We find that higher domestic COVID-19 cases reduce the probability of a country implementing a COVID-19 related import facilitating NTM against a specific *variety*. In contrast, higher foreign COVID-19 case numbers have a statistically significant impact on import facilitating NTMs. Similarly, we find that higher domestic COVID-19 case numbers correlate positively with the implementation of export restricting NTMs. At the same time, an increased COVID-19 prevalence in foreign countries causes trade policymakers to implement fewer NTMs that restrict agricultural and food exports. These results indicate that countries react to COVID-19 case numbers when implementing trade facilitating or restricting NTMs (Evenett et al., 2022). It is worth noting the observed correlations for some of the economic explanatory variables. We find that *varieties* with a higher MFN ad-valorem tariff are less likely to be targeted with an import facilitating NTM. Similarly, we find that countries target *varieties* more with import facilitating NTMs when they trade less in them and are more likely to restrict their export when they trade more in them. In addition, note that countries with a stronger domestic currency are more likely to implement import facilitating and export restricting NTMs. Last, we find that countries that are more food secure tend to be less likely to implement import facilitating NTMs. Overall, these results reveal essential correlations about the factors that determine the implementation of COVID-19 related NTMs on specific agricultural and food *varieties*.

Trade effects

We report the static treatment effects of COVID-19 related NTMs for agricultural and food trade in Table 3. The table is organized according to import and export and distinguishes between quantity, value, and unit value. We find positive treatment effects of trade facilitating NTMs for import quantity and value that are insignificant at conventional levels of statistical significance.⁴ The trade effects are larger for the import quantity (4.7%) than for the value (4.1%),

TABLE 2 Control function estimates for the determinants of COVID-19 related non-tariff measures

(a) Second stage estimates				
Dependent variable (NTM)	Import NTM		Export NTM	
	Facilitation	Restriction	Facilitation	Restriction
Log (COVID-19 cases, domestic), 1 month lag	-0.247*** (0.088)	0.001 (0.002)	-0.017 (0.011)	0.036* (0.020)
Log (COVID-19 cases, foreign), 1 month lag	20.664*** (6.469)	-0.081 (0.142)	2.360 (1.626)	-3.438* (1.893)
Log (MFN + 1)	-0.158*** (0.044)	0.001 (0.001)	-0.010 (0.007)	0.010 (0.011)
Log (trade value), 12 months lag	-0.035*** (0.011)	0.000 (0.000)	-0.003 (0.002)	0.007** (0.003)
Log (Exchange rate), 1 month lag	0.385*** (0.102)	0.002 (0.004)	0.018 (0.012)	0.193*** (0.046)
Food Security, 12 months lag	-0.052*** (0.019)	0.000 (0.000)	-0.004 (0.002)	0.005 (0.005)
Residual (COVID-19 cases, domestic)	0.277*** (0.087)	-0.001 (0.002)	0.017 (0.011)	-0.037* (0.019)
Residual (COVID-19 cases, foreign)	-20.668*** (6.469)	0.081 (0.142)	-2.360 (1.626)	3.436* (1.893)
Adjusted R^2	0.337	0.147	0.393	0.199
Observations	2,144,625	2,144,625	2,215,875	2,215,875
(b) First stage estimates				
Dependent variable (Log [COVID-19 cases], 1 month lag)	Import Specification		Export Specification	
	Domestic	Foreign	Domestic	Foreign
Log (GDP per capita), 12 months lag	0.304*** (0.005)	0.002*** (0.000)	0.305*** (0.005)	0.002*** (0.000)
Agricultural employment rate, 12 months lag	-0.223*** (0.009)	-0.004*** (0.000)	-0.234*** (0.009)	-0.004*** (0.000)
Agricultural GDP share, 12 months lag	5.258*** (0.100)	0.059*** (0.002)	5.253*** (0.099)	0.061*** (0.002)
Adjusted R^2	0.969	0.999	0.969	0.999
Kleibergen–Paap F statistic	1770.8	448.1	1806.8	453.6
Observations	2,144,625	2,144,625	2,215,875	2,215,875

Note: The table shows control function estimates for the determinants of COVID-19 related NTMs. Panel (a) shows the second stage and Panel (b) summarizes the first stage estimates. Note that all regressions include product-country and time fixed effects. For the sake of brevity, we excluded the economic covariates from the first stage regression. These estimates are available upon request from the authors. The first-stage standard errors are clustered at the product-country level, while the second-stage standard errors are bootstrapped with replacement for 1000 replications within product-country pairs.

***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

pointing toward an adverse price effect for targeted *varieties*. However, the price effect (-0.7%) is also statistically insignificant. We find strong evidence for adverse treatment effects of trade restricting NTMs for import quantity. Imports of targeted *varieties* are 77.4% lower than for the comparison group. The import value reacted less to restricting NTMs. We find an adverse trade effect of 51.6%, pointing toward positive price effects for targeted *varieties* of 3.1%. Overall, the results indicate that COVID-19 related NTMs targeting agricultural and food imports were not effective in achieving the set policy goal of facilitating additional imports.

Similarly, our regressions provide no evidence for positive trade effects of export facilitating NTMs. All parameter estimates are insignificant at conventional levels of statistical significance. We also find adverse trade effects of export restricting NTMs for export quantity and value that are statistically insignificant. Although the trade effect (-5.2%) for export quantity has the expected sign, the regression results do not allow us to reject the null hypothesis, implying that there is no effect of trade restricting NTMs on agricultural and food exports using the static regression framework. Note that the parameter estimate for export value is smaller than that for export quantity, providing some evidence for positive price effects. This effect is likely caused by higher unit values for targeted *varieties*, as indicated by the positive parameter estimate for unit value. In addition, it could be that the export restricting NTMs were effective in the early month after implementation, as the static regression approach could hide such treatment dynamics in the presence of significant pre-trends.

To assess the treatment dynamics underlying the observed trade effects, we implemented a linear panel regression approach with dynamic treatment effects (Freyaldenhoven et al., 2021):

$$\log(y_{ikt}) = \sum_{l=-12}^{12} \beta_{1,l} NTM_f_{ik,t-l} + \sum_{l=-12}^{12} \beta_{2,l} NTM_r_{ik,t-l} + \alpha_{ik} + \gamma_{it} + \delta_{kt} + \varepsilon_{ikt}, \quad (3)$$

where we use the same subscripts and fixed effects as in Equation (2). Instead of assuming static paths of the treatment coefficients, we now allow them to be dynamic before and after the treatment month. We center the event study according to the month when a *variety* was targeted by a facilitating or restricting NTM. The trade effects for facilitating and restricting NTMs are identified jointly. We use an event window of 12 months before and after the policy shift to measuring the dynamic treatment effects, binning time periods outside of the event window. Deploying the parsimonious assumption that all latent confounders are either invariant at the product-country level or captured by the country-time and product-time fixed effects, we identify the dynamic treatment effects by relying on variation between treated and untreated *varieties* over time (Carter & Steinbach, 2020; Fajgelbaum et al., 2020). All standard errors are clustered at the product-country level.

Figure 3 depicts the dynamic parameter estimates for import facilitating and export restricting NTMs. We plot the event study coefficients, 95% confidence intervals, and uniform sup-t bands for the event-time of outcome y_{ikt} (Freyaldenhoven et al., 2021). We also overlay estimates from the static model and report the corresponding p-value for a Wald test. We conducted a Wald test for pre-event trends and tested for anticipatory behavior and the presence of a confound (Freyaldenhoven et al., 2019).⁵ Because the treatment effect could be dynamic beyond the endpoints of the event window, we also conducted a Wald test for the null that the treatment dynamics level off. The Wald tests provide no evidence for significant pre-event trends at conventional levels of statistical significance for both outcomes. However, there is some evidence for leveling off treatment effects for export restricting NTMs. We find limited

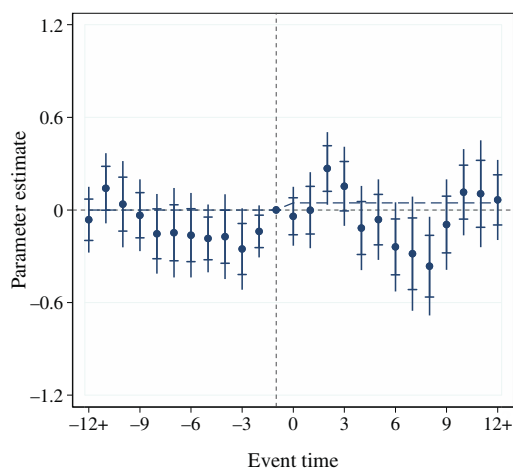
TABLE 3 Static effects of COVID-19 related non-tariff measures on agricultural and food trade

	Import			Export		
	Quantity	Value	Unit value	Quantity	Value	Unit value
<i>NTM_f</i>	0.046 (0.071)	0.040 (0.058)	-0.007 (0.026)	-0.351 (0.770)	-0.163 (0.753)	0.183*** (0.054)
<i>NTM_r</i>	-1.484*** (0.186)	-0.725 (0.637)	0.030 (0.088)	-0.053 (0.144)	-0.003 (0.120)	0.005 (0.036)
Adjusted R^2	0.939	0.886	0.979	0.943	0.889	0.978
Observations	1,419,331	1,461,339	1,418,967	1,046,727	1,080,959	1,045,930

Note: The table reports log-linear regression results for the trade effects of COVID-19 related NTMs on agricultural and food trade. Note that *NTM_f* stands for trade facilitating and *NTM_r* for trade restricting NTMs. All models include product-country, country-time, and product-time fixed effects. Standard errors are clustered at the product-country level.

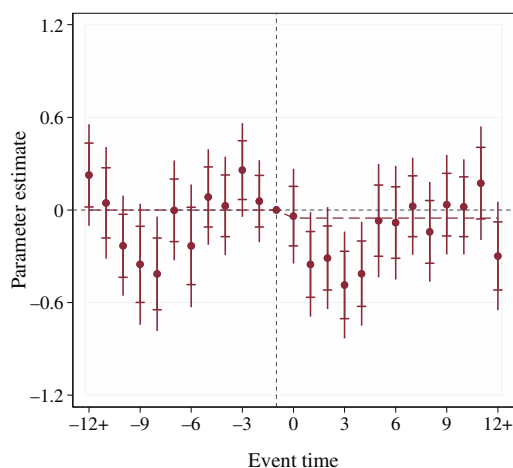
***, **, and * indicate statistical significance at 1%, 5%, and 10%, respectively.

evidence for consistently increased agricultural and food imports for treated *varieties* in the first 5 months post the treatment for trade facilitating NTMs. On average, imports increased by 5.4% during that period.⁶ These estimates are rather similar to the static regression results, pointing



Pre-trends p -value: 0.308—Leveling off p -value: 0.799—Static effect p -value: 0.630
Adjusted R-squared: 0.935—Observations: 1,419,331

(a)



Pre-trends p -value: 0.673—Leveling off p -value: 0.006—Static effect p -value: 0.777
Adjusted R-squared: 0.938—Observations: 1,046,727

(b)

FIGURE 3 Event studies for import facilitating and export restricting non-tariff measures (NTMs).

(a) Import facilitating NTMs. (b) Export restricting NTMs. Note: The figures show event studies for import facilitating and export restricting NTMs. The outcome of this regression is import or export quantity. All regressions include product-country, product-time, and country-time fixed effects. Standard errors are adjusted for within-cluster correlation at the product-country level. We plot the dynamic treatment parameters, 95% confidence intervals, and uniform sup-t bands for the event-time coefficients. Results from a static model are overlaid, and the corresponding p -value for a Wald test is provided in the figure note. We also computed Wald test results for pretrends and leveling off dynamic treatment effects. The figure note reports the adjusted R^2 and the observation numbers. [Color figure can be viewed at wileyonlinelibrary.com]

toward a limited role that pre-trends play in the identification of trade effects caused by trade facilitating NTMs. In contrast, export restricting NTMs caused a statistically significant reduction in trade flows for treated *varieties* by -27.5% during the same period. The average post-event estimates are substantially larger for the dynamic than the static model, implying the presence of treatment dynamics that the traditional static regression approach cannot credibly address. Note that the dynamic trade effects of export restricting NTMs fade away after the corresponding policies were revoked, indicating that they were effective in achieving the set policy goals and cause a limited degree of long-term trade disruptions.⁷

Table S2 summarizes a robustness analysis for the trade effects of import facilitating and export restricting NTMs. Following the framework proposed by Chaisemartin and D'Haultfoeuille (2020), we compare the baseline results in Panel (A) with regressions in which we limit the identifying variation to either cross-country in Panel (B) or cross-product variation in Panel (C). We report the average post-event treatment effects in Specification (1) and the ones for the first 5 months after NTM implementation in Specification (2). We find consistent evidence across Panels for adverse trade effects of export facilitating NTMs in Specification (2). These effects operate primarily through trade volumes as we find no evidence for statistically significant price effects.

We also investigate different estimation strategies to retain zero trade flows. We compare event studies for the inverse hyperbolic sine (IHS) transformation and the Poisson Pseudo Maximum Likelihood (PML) estimator in Figure S2. Both approaches perform well with zero observations and provide reasonable elasticity estimates (Aihounton & Henningsen, 2021; Bellemare & Wichman, 2020; Silva & Tenreyro, 2006). The event studies provide evidence for statistically significant trade effects in the first 5 months after the NTM implementation. The IHS estimates for import facilitating NTMs are statistically indifferent to the baseline event study estimates. At the same time, we find evidence for larger adverse trade effects of 35.9% for export restricting NTMs. The Poisson PML estimates provide a similar picture for both NTM types, although the treatment effects are more noisily estimated for export restricting NTMs.

CONCLUSIONS

Modern agricultural and food trade policy involves the frequent use of NTMs to achieve a wide array of trade, such as restricting imports or exports, and non-trade policy goals, such as ensuring product safety, environmental protection, and national security (Grundke & Moser, 2019; Herghelegiu, 2018). Regardless of their purpose, NTMs can have various implications for the direction and volume of international trade (Santeramo & Lamonaca, 2019). Since the coronavirus pandemic began, more than 58 countries have implemented NTMs that targeted the agricultural and food sector. This paper is the first to thoroughly examine the determinants and trade effects of these temporary trade measures. Combining an NTM dataset with monthly trade data at the product level, we tease out the treatment effects of COVID-19 related NTMs by relying on variation between treated and untreated *varieties* (product-country pairs) over time. Implementing a control function approach, we find that an increase in domestic COVID-19 case numbers reduces the probability of a country implementing an import facilitating NTM. In contrast, we find that an increase in the foreign COVID-19 prevalence rate has a statistically significant impact on import facilitating NTMs. We document the opposite correlations between increasing COVID-19 case numbers and export restricting NTMs. These findings point toward the interplay between public health and trade

policies, indicating that the pandemic progression played an essential role in the decision of countries to implement import facilitating and export restricting NTMs against agricultural and food varieties.

Using a credible causal inference design that relies on variation between treated and untreated varieties over time, we assess the trade effects of COVID-19 related import facilitating and export restricting NTMs for agricultural and food products. Our results indicate a heterogeneous response of international trade to COVID-19 related NTMs. We find that the trade volume of targeted varieties is 4.7% higher for import facilitating and 5.7% lower for export restricting NTMs in the static model specification. Both estimates are insignificant at conventional levels of statistical significance. We find that the static estimates hide substantial heterogeneity across time. The dynamic treatment effects are more substantial within the first 5 months after implementing COVID-19 related NTMs. The average post-event trade effect for import facilitating NTMs (5.4%) is smaller than for export restricting NTMs (−27.5%). These differences indicate that the static regression approach cannot credibly address the considerable treatment dynamics. The average post-event trade effects are less relevant for import facilitating than for export restricting NTMs, pointing toward the fact that a temporary trade barrier can be highly effective in times of public emergencies to achieve specific trade policy goals. After revoking these temporary trade measures, the dynamic trade effects fade away, implying that COVID-19 related NTMs caused only a limited degree of long-term trade disruptions.

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ENDNOTES

- ¹ Note that the policy implementation is highly clustered around March and April 2020. Hence, we are not concerned about the research design being biased due to staggered adoption (Athey & Imbens, 2022) and differences in treatment timing (Goodman-Bacon, 2021).
- ² We also conduct a robustness check that allows the treatment effects to vary before and after the policy change. The dynamic estimates for (2) are reported in Section 2.2.
- ³ Note that we dropped singletons at the variety level from this dataset following the approach outlined by (Correia et al., 2019).
- ⁴ We obtained the trade effects for the log-linear regression by transforming the parameter estimates with the formula $\exp(\hat{\beta}_k) * 100$ (Silva & Tenreyro, 2006). Note that the static approach could lead to estimation bias in the presence of dynamic treatment effects (Freyaldenhoven et al., 2019).
- ⁵ Because a failure to reject the null hypothesis of no pre-event trends does not imply that there is no confound, we also estimate a devil's advocate model which assumes that the true value of the treatment effect is zero (Roth, 2020). We follow Rambachan and Roth (2019) and identify the least “wiggly” event-time path, which is, among polynomial confounds consistent with the estimated event-time path, the least “wiggly” path with the lowest polynomial order, and the coefficients with the lowest possible magnitude. We find that the event-time path for each outcome is “wiggly,” making the existence of a confounding and unobserved variable implausible and implying that import facilitating and export restricting NTMs do causally affect agricultural and food trade. The corresponding parameter estimates are available upon request from the authors.

- ⁶ We computed the average post-event estimates to summarize post-treatment dynamics following de Chaisemartin and D'Haultfoeulle (2020). An alternative approach is to report the contemporaneous treatment effect for β_1 and β_2 from the static model as overlaid in Figure 3 (Gentzkow et al., 2011). Note that this static approach is biased in the presence of dynamic treatment effects.
- ⁷ Most COVID-19 related NTMs were revoked by Fall 2020. See Figure 1 for the timeline of import facilitating and export restricting NTMs targeting the agricultural and food sector and Figure S1 for the corresponding changes in treated *varieties*.

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