



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Agri-food trade resilience among food-deficit countries during the COVID-19 pandemic

RESEARCH ARTICLE

Soojung Ahn^a & Sandro Steinbach^b

^a*Phd Student, Department of Agricultural and Resource Economics, University of Connecticut, 1376 Storrs Road, Unit 4201, Storrs, CT 06269-4021, USA*

^b*Associate Professor and CAPTS Director; Agribusiness and Applied Economics, North Dakota State University, 1230 Albrecht Blvd, Fargo, ND 58102, USA*

Abstract

This paper examines the trade resilience of low-income and food-deficit countries (LIFDCs) during the COVID-19 pandemic. Since the pandemic declaration, LIFDCs have faced unique challenges due to their heavy reliance on food imports. This paper identifies the differential trade effects of COVID-19 lockdowns on agri-food exports to LIFDCs using a dynamic treatment effects model and monthly product-level agri-food trade data. The baseline results show a sharp decrease in agri-food exports to LIFDCs in the first three months after the pandemic declaration and a gradual recovery afterward. Additional analyses at the product and country levels show that LIFDCs focused on securing cereal products from foreign sources and that imports of other agri-food products contracted considerably relative to the counterfactual. The foreign supply chains of LIFDCs were less resilient in the first quarter after the treatment than those of other low-income countries, but their recovery was also faster than in those other countries. The paper provides the empirical underpinning for concerns raised by international organizations regarding the resilience of agri-food supply chains and COVID-19 containment measures, revealing the differential impact that lockdowns had on agri-food trade resilience in the developing world.

Keywords: COVID-19, lockdown measures, LIFDCs, agri-food trade resilience, food security

JEL code: Q17, Q18, F14, F63

[ⓧ]Corresponding author: soojung.ahn@uconn.edu

1. Introduction

The world economy experienced considerable disruptions from the COVID-19 pandemic that amplified in early 2020. Most countries responded to the infectious disease by implementing various rules and regulations that limit the physical movement of people, merchandise, and services across international borders (Ahn and Steinbach, 2021, in press; Bieber, 2022; Guan *et al.*, 2020). As a result, the impact of COVID-19 on global supply chains and trade turned out to be heterogeneous across countries and economic sectors (Arita *et al.*, 2022). Most developed economies deployed strict foreign and domestic policies to combat the disease. At the same time, the world's most vulnerable countries, the low-income and food-deficit countries (LIFDCs), have faced major challenges in their food system due to their high reliance on food imports (Espitia *et al.*, 2020).¹ Elevated food prices, amplified by increasing transport costs, export restrictions, and import prohibitions, increased pre-existing vulnerabilities in those countries to the point where they had considerable implications for food security (IFPRI, 2020). Several empirical studies have examined the economic and trade implications of the COVID-19 pandemic. Previous *ex-ante* research focused on predicting trade flows and assessing potential economic implications (Maliszewska *et al.*, 2020; McKibbin and Fernando, 2021; Sumner *et al.*, 2020). *Ex-post* studies looked primarily at the trade effects of COVID-19 lockdown measures (e.g. Arita *et al.*, 2022; Hayakawa and Mukunoki, 2021). Arita *et al.* (2022) found a slowdown in agricultural trade during the pandemic, but these effects are smaller than those observed for manufacturing trade. Hayakawa and Mukunoki (2021) showed that the impact of stay-at-home orders on overall trade is statistically insignificant, but the trade effects on durable and essential products are adverse.

This paper assesses the trade resilience of LIFDCs during the COVID-19 pandemic. Those countries faced unique challenges due to their heavy reliance on food imports (FAO, 2022). The trade effects of COVID-19 lockdowns are analyzed through an augmented gravity model that accounts for dynamic treatment effects (Arita *et al.*, 2022; Carter *et al.*, in press; Grant and Lambert, 2008). The analysis builds on a comprehensive dataset covering monthly product-level trade data for 100 exporters and 197 importers from January 2016 to April 2021. Mirrored trade data are used because the reporting quality and general availability of high-frequency and detailed trade data for LIFDCs are limited. An event window of twelve months around each exporter's first lockdown was constructed to assess the potential existence of treatment dynamics. The paper follows Carter *et al.* (in press) by setting up the treatment group with 2019/2021 trade data for the twelve-month before and after the event of interest and constructing a control group with trade data from 2016 to 2019 for the same event window. In addition, high-dimensional fixed effects that vary at the exporter-importer-product level over time are used to account for unobserved supply and demand shocks. LIFDCs food imports concentrate in staple foods (FAO *et al.*, 2020). When food insecurity becomes more severe, food consumption and dietary intake decrease, while staple food makes up a larger share of the diet. Food insecurity has been exacerbated during the pandemic, particularly among poor households (Amare *et al.*, 2021; Hirvonen *et al.*, 2021). To account for this feature, several sub-samples are analyzed. First, the product-level trade resilience is assessed². The choice of staple foods is based on the top agri-foods exported to LIFDCs. Second, to reveal potential heterogeneity among countries, the average post-event treatment effects are compared for LIFDCs and non-LIFDCs.

The empirical findings reveal that agri-food exports to LIFDCs were significantly affected by COVID-19 containment measures. Agri-food trade shrunk by 17% in the first three months after the first lockdown measures were implemented. However, LIFDCs also experienced a strong recovery from the trade shock afterward, expanding agri-food imports beyond the pre-pandemic level nine months after the first lockdowns. The estimates indicate considerable heterogeneity among agri-food product groups, indicating a substitution

¹ LIFDCs are designated by their gross national income per capita and the difference between their exports and imports of foodstuffs (FAO, 2022). The 2021 list consists of 47 countries which are mainly in Africa.

² Staple foods are defined as foods that make up the dominant part of the diet and are consumed regularly in sufficient quantities to satisfy most energy needs (FAO *et al.*, 2020).

toward staple crops and adverse trade effects for sugars and prepared foodstuffs. The economic development stage has considerable implications for the trade resilience of LIFDCs. Agri-food exports to low-income countries were more sluggish in recovery, with little movement observable until twelve months after the first lockdowns. The average post-treatment effects for the lower-middle income group had similar treatment paths throughout the four quarters after the first lockdown declaration. These estimates suggest that the containment measures reduced agri-food imports of LIFDCs more than in low- and lower-middle income countries early on. However, their trade recovery was also relatively slow, indicating limited short-run trade resilience among LIFDCs. Several robustness checks confirm the validity of the identification strategy and baseline findings. They are robust to a linear regression specification without zero trade flows, different control groups, and pre-trends.

The paper contributes to the growing literature concerned about the trade resilience of LIFDCs. At the beginning of the COVID-19 pandemic, several governments started to reserve food by imposing export bans on staple foods (Laborde *et al.*, 2021; Swinnen and McDermott, 2020). In addition, the lockdown measures disrupted global food supply chains, increasing food supply issues in those countries (Laborde *et al.*, 2021). This paper expands on the earlier empirical literature on the COVID-19 lockdown impacts on international trade (Arita *et al.*, 2022; Hayakawa and Mukunoki, 2021). These studies find a negative impact of lockdown orders on the agri-food trade, but little is known about its impact on trade resilience among LIFDCs. Accounting for treatment dynamics in a gravity-consistent empirical model, the paper reveals considerable heterogeneity in the trade response across country and product groups from a food security perspective. Our findings provide the empirical underpinning for concerns raised by international organizations about containment measures and agri-food trade resilience among LIFDCs during the COVID-19 pandemic.

2. LIFDCs trade during the COVID-19 pandemic

LIFDCs include 29 low-income and 18 lower-middle-income countries. Around 76% of those countries are located on the African continent. LIFDCs spend a high proportion of their national income on food. An average household spends about 50% of its income on food, while that share is only 15% in high-income countries (Kugelman and Hathaway, 2010). Thus, even small food price increases or supply chain disturbances can considerably affect livelihood and food intake in low-income countries. LIFDCs are vulnerable in all four key dimensions of food security (Committee on World Food Security, 2014). Because there is a strong relationship between food security and international agri-food trade, additional agri-food imports can solve food insecurity. Figure 1A depicts agri-food exports to LIFDCs from January 2016 to April 2021. Agri-food exports to those countries have grown considerably over time. This increase is driven by rapid population growth rather than household income increases (Van Berkum, 2021). At the beginning of the COVID-19 pandemic, a sharp decrease in agri-food exports to LIFDCs occurred. After that initial shock, agri-food exports to LIFDCs recovered and outgrew the pre-pandemic level in value terms due to higher import prices. Global agri-food trade has shown some resilience to the pandemic disruptions, but sharp price hikes have led to significant challenges for low-income countries (United Nations, 2022). Food price has increased considerably. Higher input and shipping costs and unfavorable foreign currency exchange drive these price hikes.

Figure 1B shows the top ten agri-food products exported to LIFDCs based on data from 2016 to 2019. Since staple crops are essential in most developing countries, it is no surprise that cereals are the largest category of agri-food products exported to LIFDCs (HS 10). They occupy more than one-fourth of the food exports. In addition, cereal preparations (HS 19) and milling products (HS 11) also occupy a high share. The second largest agri-food category exported to LIFDCs is fats and oil extracted from animals and vegetables (HS 15). Dietary fat is an essential contributor to energy, and the availability of cheap vegetable oils and fats has led to a significant increase in fat consumption in these countries (Drewnowski and Popkin, 1997). The high proportion of sugar imports is related to increasing sales of sweetened beverages in many underdeveloped countries (Van Berkum, 2021). Miscellaneous edible preparations (HS 21) are ranked in the top five. Coffee,

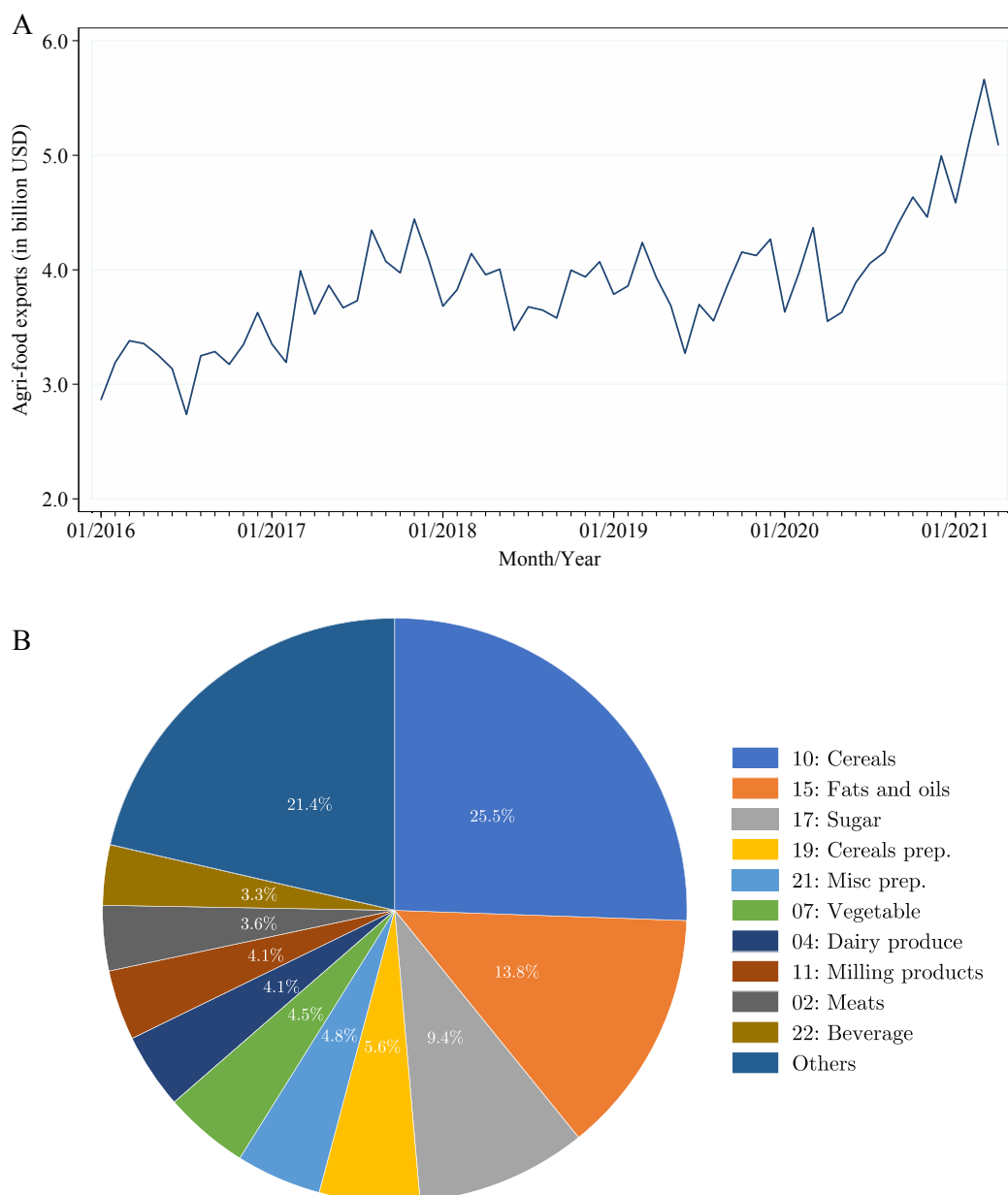


Figure 1. Trends in agri-food exports to LIFDCs. (A) Agri-food exports to LIFDCs, (B) Top 10 agri-food product categories showing trade shares at the HS-chapter level based on the average for 2016 to 2019.

tea, dressings, soups, and ice creams are included in that chapter. The next largest category is vegetables (HS 07). It is not only an essential source of fiber and micronutrients but also contains staple food products such as potatoes, beans, and corn. In addition, the other top items supplied from outside are protein-intensive, such as dairy produce (HS 04) and meats (HS 02). These ten agri-food products are expected to be affected by supply disruptions caused by COVID-19 lockdown measures.

3. Empirical approach and data

3.1 Empirical approach

To estimate the trade effects of COVID-19 lockdowns on agri-food trade resilience among LIFDCs, a non-linear regression model with dynamic treatment effects is used. This statistical approach identifies the differential trade impact of COVID-19 lockdowns relative to the event of interest (Freyaldenhoven *et al.*, 2021). An event window for each exporter-importer-product pair was constructed based on the exporter's first lockdown month. Most governments imposed the first COVID-19 lockdown in March 2020, the same month as the official World Health Organization (WHO) pandemic declaration. However, there is some variation among countries according to the first lockdown month in the range from January to April 2020. Thus, it is crucial to consider the differential impact of the lockdown month and use a credible counterfactual to infer the causal treatment effects. Drawing from the identification strategy proposed by Arita *et al.* (2022) and Carter *et al.* (in press), the treatment group is constructed with trade data from 2019 to 2021. The control group includes trade data from 2016 to 2020 for the same event window. An event window of twelve months around each exporter's initial lockdown order was used to test for potential pre-trends and leveling-off treatment effects. We choose twelve months for the event window to be able to study treatment dynamics. The baseline model is defined as follows:

$$X_{ijk,t} = \exp \left(\alpha_{ijk,y} + \gamma_{ijk,m} + \sum_{c=-12}^{12} \beta^c \text{Treatment}_{ijk,t-c} \right) \varepsilon_{ijk,t} \quad (1)$$

Where i stands for the exporter, j for the importer, k for the HS chapter (two-digit level), and t for the month, respectively. The outcome of interest $X_{ijk,t}$ measures agri-food exports from country i to j at the HS chapter level. To control for unobserved demand and supply shifters and trade cost factors, time-varying exporter-importer-product fixed effects, indicated by $\alpha_{ijk,y}$ and $\gamma_{ijk,m}$ are included. This specification of the event-time fixed effects allows us to control for seasonality, bilateral trade policies, other trade shocks on certain products, and any specific bilateral attributes. The event year is denoted with y and the event month with m . The term $\sum_{c=-12}^{12} \beta^c \text{Treatment}_{ijk,t-c}$ measures the dynamic treatment effects of COVID-19 lockdowns on agri-food trade resilience of LIFDCs. Lastly, $\varepsilon_{ijk,t}$ denotes the multiplicative error term.

Two factors drive the choice of using export data instead of import data for LIFDCs. First, data reporting quality for LIFDCs is problematic because most LIFDCs report less comprehensive trade data that suffer from significant reporting delays and errors (Manners and Behar, 2009). Second, lockdown orders disrupted global supply chains in many exporting countries, while importing countries have also been hurt by domestic supply chain disruptions (Zajc Kejžar *et al.*, 2022). Therefore, this study uses exports to LIFDCs to measure the trade effect of COVID-19 lockdown orders. For reliability and accuracy, a comprehensive panel of export flows to LIFDCs that includes 100 reporting countries is used.

The Poisson pseudo maximum likelihood (PPML) estimator is used to identify the dynamic treatment effects of COVID-19 lockdowns. The non-linear estimator is commonly applied to identify trade policy effects because it effectively handles zero trade flows and accounts for heteroscedasticity (Larch *et al.*, 2019; Silva and Tenreyro, 2006; Weidner and Zylkin, 2021). A modified version of the iteratively re-weighted least-squares (IRLS) algorithm for statistical separation and convergence problems is applied to deal with high-dimensional fixed effects and identify the parameters of interest (Correia *et al.*, 2020). All standard errors are clustered at the exporter-importer-product level, following standard practice in the trade literature by assuming that the standard errors are correlated at that level (Weidner and Zylkin, 2021).

3.2 Data

Monthly bilateral export data were extracted from the Global Trade Atlas from January 2016 to April 2021 (IHS Markit, 2022 – <https://global.ihs.com/>). The balanced dataset covers 100 reporters and 197 partner countries at the 2-digit HS chapter level. Agri-food products were defined based on HS chapters 01 to 24 (USITC, 2022). These chapters can be aggregated into four sections: (1) live animals and animal products, (2) vegetable products, (3) animal or vegetable fats, etc., and (4) prepared foodstuffs, beverages, etc. Data on the first lockdown month for each exporting country was collected from the WHO and public sources. Most exporting countries imposed the first lockdown order in March 2020. For countries that do not have an official lockdown order in 2020, the WHO's pandemic declaration month was applied as the country's event month. Importing countries were grouped according to their development stage into low, lower-middle, upper-middle, and high-income countries based on the World Bank (2022). Lastly, Food and Agricultural Organization (FAO, 2022) definition is applied to define LIFDCs. The final dataset includes all 47 LIFDCs.

4. Results and discussion

4.1 Baseline results

Figure 2 presents parameter estimates for the impact of COVID-19 lockdowns on agri-food exports to LIFDCs. The event study plots for value and quantity specification show the dynamic treatment parameter estimates and uniform sup-t 95% confidence bands. The statistical tests below each figure provide information on the significance of the pre-trends and leveling-off treatment effects. The static model estimates are depicted as a dashed line in the post-period, while the corresponding p-values are reported below each figure (Freyaldenhoven *et al.*, 2021). The Pseudo R-squared and observation numbers for the dynamic treatment models are also shown below. Figure 2A presents estimates for the value and Figure 2B for the quantity specification. The post-treatment coefficients indicate a significant reduction in agri-food exports to LIFDCs in the first four months of the post-event period. LIFDCs experienced a sharp supply shock in the early stages of COVID-19 due to the initial lockdown policies implemented by the exporting countries.

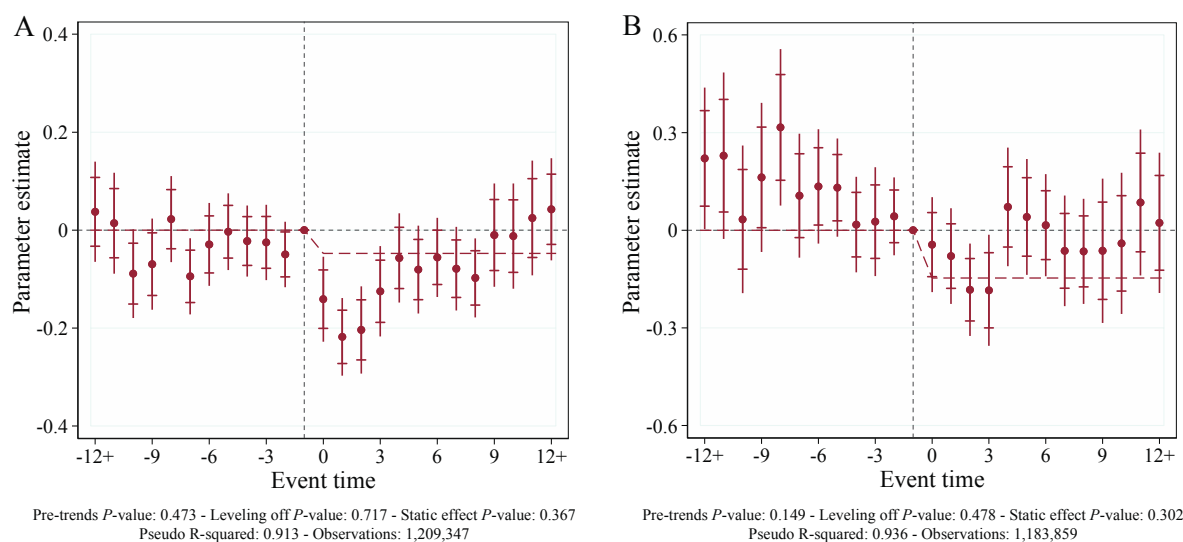


Figure 2. Trade resilience among LIFDCs during the COVID-19 pandemic. (A) Value and (B) Quantity. All regressions include exporter-importer-product-event year and exporter-importer-product-event month fixed effects. Standard errors are adjusted for within-cluster correlation at the exporter-importer-product level. Each figure shows the dynamic treatment parameters and uniform sup-t confidence bands. It also shows Wald test results for pre-trends, leveling off dynamic treatment effects, and a static model. Pseudo R-squared and the observation numbers are provided in the figure note.

The estimates for the value specification in Figure 2A indicate that agri-food exports were about 7.5% below the counterfactual in the post-treatment period. This result implies that LIFDCs have struggled to secure agri-food products because of external supply shocks during the first twelve months of lockdowns. After the initial trade shock, the observed trade effects went up and down and recovered to the previous trade level after nine months. The estimates for the quantity specification in Figure 2B show a similar treatment path in the initial post-event time. The average post-trade effect for the quantity specification is -3.6%. However, the dynamic post-trade effects show a different treatment pattern six months after the first lockdowns. Note that the dynamic treatment paths increased over time for the value specification, but those for the quantity specification fluctuated at the end of the post-event period, pointing toward positive export price effects. Overall, both estimated treatment paths show a sharp decline in agri-food exports to LIFDCs at the beginning of the first lockdowns that is larger than for developed countries. The results indicate that these countries suffered in their ability to access agri-food products from foreign markets and experienced considerable price hikes. Because the pre-trend tests are all statistically insignificant, there is strong support for the robustness of the empirical approach and findings.

4.2 Robustness checks

Several additional regressions were conducted to assess the robustness of the baseline model. Figure 3 summarizes these estimations. Figure 3A depicts dynamic treatment effects using a log-linear regression model that drops all zero outcomes. The estimation results show that agri-food products exported to LIFDCs declined by 4.7% during the first twelve months after the lockdown. Figure 3B shows results for a non-linear regression using different years to construct the control group. The alternative control group was constructed with trade data for 2015/2017 to 2017/2019. With the alternative control group, agri-food exported to LIFDCs decreased by 9.2%, suggesting that the lockdown effect for LIFDCs was even worse than the baseline model. Figure 3C looks at unit values as the primary outcome of interest. The estimated event-time paths follow a smooth path, close to linear in the post-event period. The average treatment effect increased is about 3.7% in the post-event period. This result supports the baseline results, which showed that the initial drop in trade level was due to a decrease in the volume as there was no significant effect on unit values during that period. Therefore, the increase in the parameter estimate for the export value specification is largely driven by the unit value rise. Lastly, Figure 3D presents the dynamic treatment effect using aggregates agri-food exports instead of product-level data. The estimates indicate that the total agri-food exports to LIFDCs fell by 4.1% on average in the post-event period. The estimated average treatment effect is similar but smaller than that in the baseline specification and statistically less significant. A reason for this difference is that the aggregated data approach cannot account for product-specific supply and demand shifters.

4.3 Product and country heterogeneity

The trade effects of COVID-19 lockdowns are likely to vary across agri-food products as LIFDCs might have changed their trade patterns to keep their food supply chain resilient after the initial supply chain blockages. In addition, the lockdown effects are likely to be heterogeneous across countries due to differences in underlying conditions and exposure to the pandemic. To explore product heterogeneity, agri-food products were divided into four product groups, and the top 10 agri-food list were taken from Figure 1 for a detailed analysis. Figure 4A presents the treatment heterogeneity by quarter after treatment and by product group in the post-event period. The corresponding HS chapter of each group is described in the figure note. In the first quarter after the lockdown, the trade effects for (1) live animals and animal products and (4) prepared foodstuffs, beverages, and tobacco were all negative and did not recover until the fourth quarter. In contrast, vegetables and oils are less affected by the COVID-19 lockdown and experienced a fast recovery after the second quarter. This result reveals that for LIFDCs, vegetables (including cereals) and oils are essential for food security. Two possible explanations could explain these results. First, LIFDCs likely had difficulties obtaining animal protein products and prepared foodstuffs from trade after the first lockdown measures. Second, LIFDCs might have concentrated on securing cereals and oils rather than animal protein products and prepared foodstuffs during the pandemic.

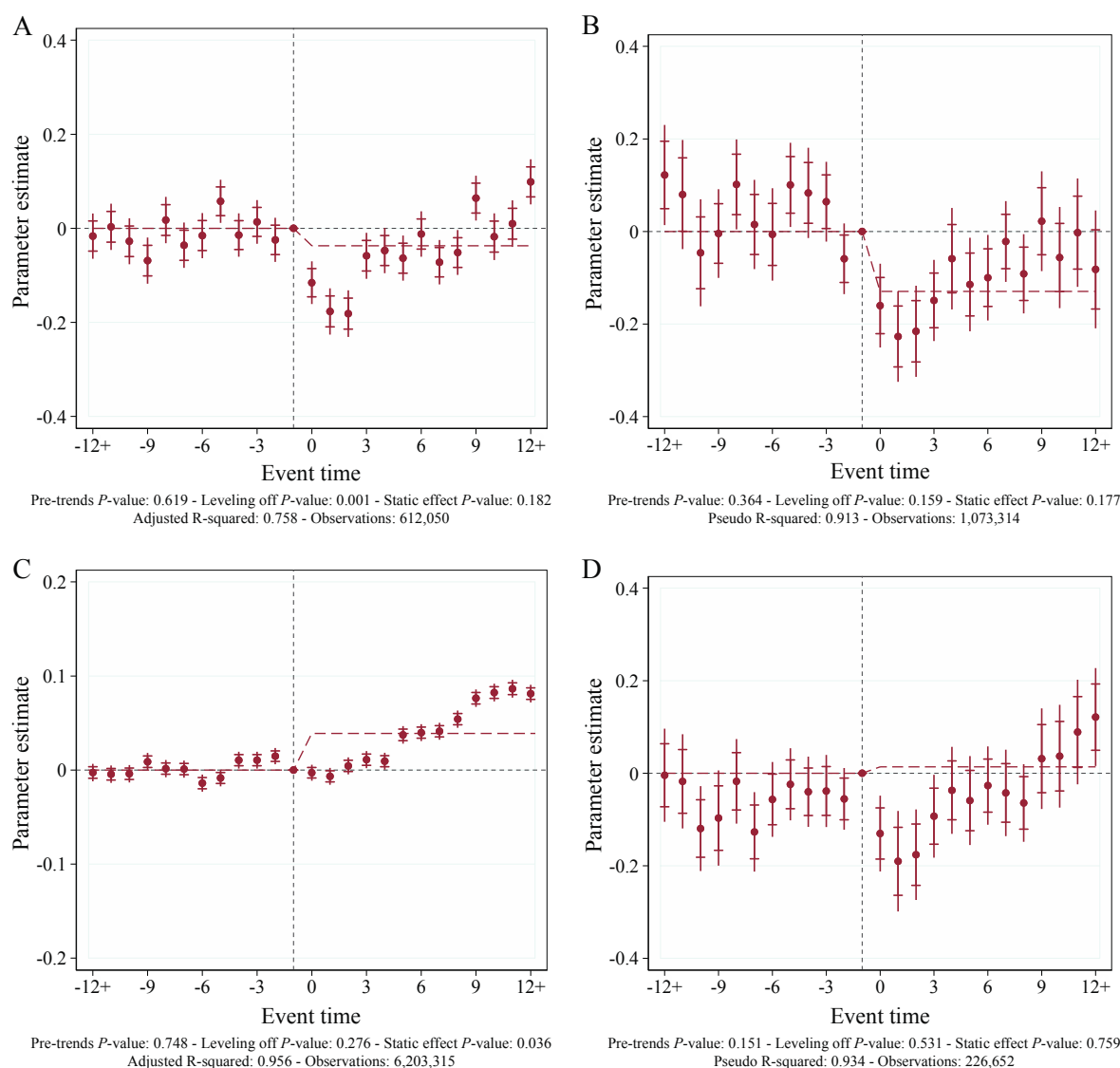


Figure 3. Robustness check for agri-food exports to low-income food-deficit countries. The four figures show robustness checks for dynamic treatment effects. (A) Log-linear regression of trade effects using ordinary least squares (OLS) estimates only with positive export values. (B) Dynamic treatment effects using a control group from event-year 2015 to 2017. (C) Dynamic treatment effects on unit value. (D) Dynamic treatment effects using aggregate agri-food export values.

Figure 4B compares the average post-event trade effects by product category during the first six months and the following six months after the lockdown policies. The figure shows that cereals and vegetable exports to LIFDCs did not decrease post-event. On the contrary, the trade effect on cereals increased from 8 to 18% during the first six months, and the vegetable trade went up from 3 to 5% in the second six months. LIFDCs have strategically concentrated on staple foods during the pandemic, which is in line with the fact that cereals have long been the predominant nutrition source for LIFDC imports (Pingali and Stringer, 2003). Fats and oils are another source of energy for LIFDCs. The trade effect on these products has increased in the second six months. In contrast, trade levels of animal protein products, sugar, etc., did not show strong recovery, indicating less supply chain resilience for those products. Lastly, in the case of beverages (HS 22), the difference in the trade effects between the first and second event times is remarkable. This chapter contains ethyl alcohol (HS2207.10), which was difficult to obtain in the early days of COVID-19. However, the supply chain disruptions for LIFDCs seem to have improved six months after the first lockdown.

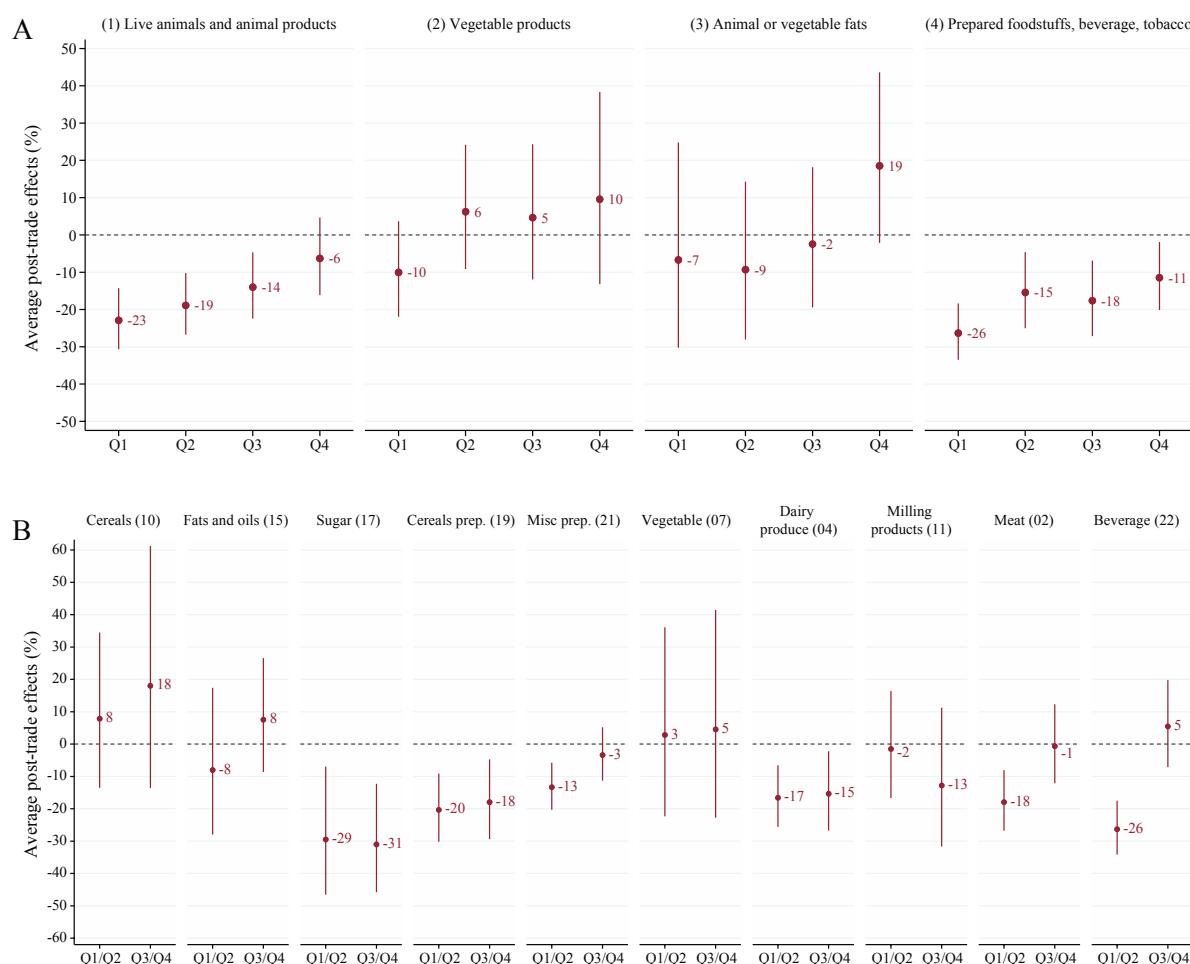


Figure 4. Treatment heterogeneity by HS section and chapter. (A) Average post-treatment effects by HS section. Section (1) includes HS 01-05; Section (2) includes HS 06-14; Section (3) includes HS 15; and Section (4) includes HS 16-24. (B) Top 10 agri-food products exported to LIFDCs. Each label indicates a representative product of the HS chapter, and the HS chapter numbers are presented in parentheses.

Figure 5 presents the average post-event trade effects of lockdown measures on agri-food exports to LIFDCs and developing countries by quarter. Developing countries were classified into low-income, lower-middle income, and upper-middle income countries. LIFDCs consist of low and lower-middle-income countries, but these country groups show different patterns of trade effects throughout the post-event period. In the first quarter, the trade effects on LIFDCs were the worst (-17%), even more than the ones observed for the low-income group. Since LIFDCs depend heavily on external food supply, supply disruption by lockdowns might have negatively affected their food security. However, from the second quarter, their trade began to recover and became positive relative to the counterfactual in the fourth quarter. This fast-track recovery is not found in low-income countries, though. There are no changes in their post-trade effect over time, and only a small increase (3%) from the first to the fourth quarter is observed. Agri-food exports to the lower middle-income group followed similar event-time paths to LIFDCs, while upper middle-income countries show positive post-treatment trade effects for the first, third, and fourth quarters. These countries seem to be the only income group not severely affected by the COVID-19 lockdown. Overall, even though supply chain resilience was undermined considerably among LIFDCs, their food system was more resilient compared to the low-income group.

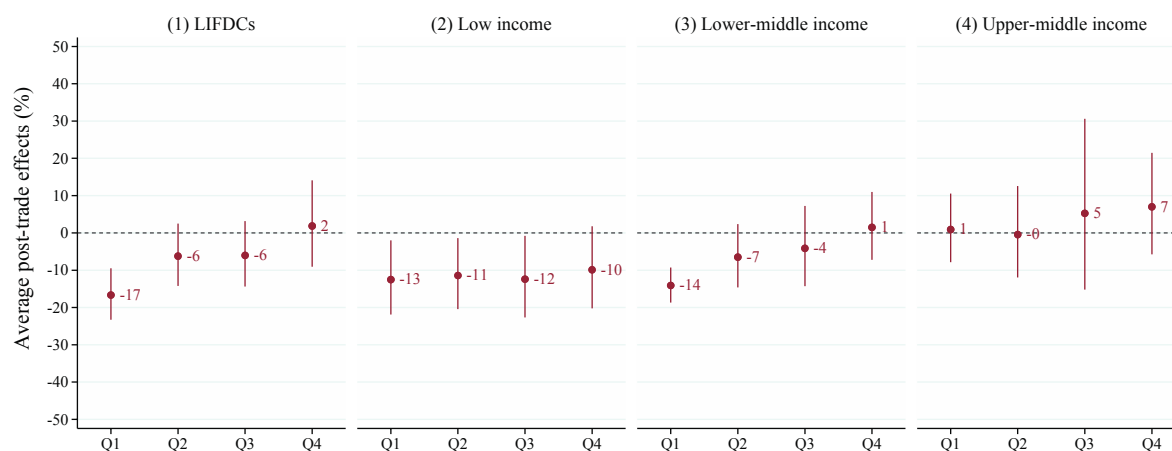


Figure 5. Country-level heterogeneity in post-event treatment effects. The developing countries were classified into low-income, lower-middle income, and upper-middle income countries following the World Bank definition. LIFDCs include low and lower-middle-income countries.

5. Conclusions

International trade is an essential channel for food supply in LIFDCs as they depend highly on food imports for their national food security. At the beginning of the COVID-19 pandemic, several governments started to reserve food by imposing export bans on staple foods (Laborde *et al.*, 2021; Swinnen and McDermott, 2020). In addition, the lockdown measures disrupted global food supply chains, increasing food supply issues worldwide (Laborde *et al.*, 2021). Our research expands on the earlier empirical literature on the lockdown impacts on international trade (Arita *et al.*, 2022; Hayakawa and Mukunoki, 2021). These studies found that although lockdown measures hurt international trade, food supply chains were resilient compared to non-agricultural trade. Our results show that lockdown measures affected LIFDCs more than other countries, deteriorating their food system resilience due to their high dependence on food imports. We find an average post-event trade effect of -7.5%. In value terms, LIFDCs decreased their agri-food imports by approximately 312.9 US million dollars in the first twelve months after the COVID-19 lockdowns. The dynamic treatment model results show that the COVID-19 lockdowns led to a drastic decrease in agri-food exports to LIFDCs in the first six months after the treatment month. The empirical results reveal considerable heterogeneity in the trade response across product and country groups from a food security perspective. These countries changed their trade patterns by concentrating on securing the supply of staple foods, such as cereals, vegetables, fats, and oils. Agri-food exports to LIFDCs were most affected in the first quarter after the lockdowns, with a 17% trade decrease, but their trade recovered to the previous level showing that agri-food exports to LIFDCs were resilient. In contrast, agri-food exports to low-income countries did not recover even after twelve months. We contribute to the growing literature that assesses the implications of trade shocks caused by COVID-19 lockdowns from a developing country perspective paying particular attention to food security challenges. Our findings provide the empirical underpinning for concerns raised by international organizations about containment measures and the resilience of agri-food trade, considering the differential impact of COVID-19 in the developing world. To improve the resilience of agri-food trade, the authorities in LIFDCs and international organizations may need to increase food reserves, ensure diversity of agri-food suppliers, and build robust transport networks for future trade shocks.

Acknowledgements

This work was supported by the National Institute of Food and Agriculture through the Agriculture and Food Research Initiative Award 2019-67023-29343. Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the United States Department of Agriculture.

References

- Ahn, S. and S. Steinbach. 2021. COVID-19 trade actions in the agricultural and food sector. *Journal of Food Distribution Research* 52 (2): 51-75.
- Ahn, S. and S. Steinbach. in press. The impact of COVID-19 trade measures on agricultural and food trade. *Applied Economic Perspectives and Policy*. <https://doi.org/10.1002/aep.13286>
- Amare, M., K.A. Abay, L. Tiberti and J. Chamberlin. 2021. COVID-19 and food security: Panel data evidence from Nigeria. *Food Policy* 101: 102099.
- Arita, S., J. Grant, S. Sydow and J. Beckman. 2022. Has global agricultural trade been resilient under coronavirus (COVID-19)? Findings from an econometric assessment of 2020. *Food Policy* 107: 102204.
- Bieber, F. 2022. Global nationalism in times of the COVID-19 pandemic. *Nationalities Papers* 50(1): 13-25. <https://doi.org/10.1017/nps.2020.35>
- Carter, C.A., S. Steinbach and X. Zhuang. in press. Supply chain disruptions and containerized agricultural exports from California ports. *Applied Economic Perspectives and Policy*. <https://doi.org/10.1002/aep.13311>
- Committee on World Food Security. 2014. Global strategic framework for food security and nutrition. Available at: <https://www.fao.org/right-to-food/resources/resources-detail/en/c/147625/>
- Correia, S., P. Guimarães and T. Zylkin. 2020. Fast Poisson estimation with high-dimensional fixed effects. *Stata Journal* 20(1): 95-115.
- Drewnowski, A. and B.M. Popkin. 1997. The nutrition transition: new trends in the global diet. *Nutrition Reviews* 55(2): 31-43.
- Espitia, A., N. Rocha and M. Ruta. 2020. *Covid-19 and food protectionism: the impact of the pandemic and export restrictions on world food markets*. World Bank Policy Research Working Paper (9253). World Bank, Washington, DC, USA.
- Food and Agriculture Organization of United Nations (FAO). 2022. Low-income food-deficit countries (LIFDCs) – List updated June 2021. Available at: <https://www.fao.org/countryprofiles/lifdc/en/>.
- FAO, IFAD, UNICEF, WFP and WHO. 2020. *The state of food security and nutrition in the world 2020. Transforming food systems for affordable healthy diets*. FAO, Rome, Italy. <https://doi.org/10.4060/ca9692en>
- Freyaldenhoven, S., C. Hansen, J.P. Pérez and J.M. Shapiro. 2021. *Visualization, identification, and estimation in the linear panel event-study design* (No. w29170). National Bureau of Economic Research, Cambridge, MA, USA.
- Grant, J.H. and D.M. Lambert. 2008. Do regional trade agreements increase members' agricultural trade? *American Journal of Agricultural Economics* 90(3): 765-782.
- Guan, D., D. Wang, S. Hallegatte, S. J. Davis, J. Huo, S. Li, Y. Bai, T. Lei, Q. Xue, D. Coffman, D. Cheng, P. Chen, X. Liang, B. Xu, X. Lu, S. Wang, K. Hubacek, and P. Gong. 2020. Global supply-chain effects of COVID-19 control measures. *Nature Human Behaviour* 4(6): 577-587.
- Hayakawa, K. and H. Mukunoki. 2021. Impacts of lockdown policies on international trade. *Asian Economic Papers* 20(2): 123-141.
- Hirvonen, K., A. de Brauw, and G. T. Abate. 2021. Food consumption and food security during the COVID-19 pandemic in Addis Ababa. *American Journal of Agricultural Economics* 103(3): 772-789.
- International Food Policy Research Institute (IFPRI). 2020. *COVID-19 and global food security*. Available at: <https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/133762/filename/133971.pdf>.

- Kugelman, M. and R. Hathaway. 2010. *Hunger pains: Pakistan's food insecurity*. Woodrow Wilson International Center for Scholars: Washington, DC, USA. Available at: <https://www.wilsoncenter.org/publication/hunger-pains-pakistans-food-insecurity>.
- Laborde, D., W. Martin and R. Vos. 2021. Impacts of COVID-19 on global poverty, food security, and diets: Insights from global model scenario analysis. *Agricultural Economics* 52(3): 375-390.
- Larch, M., J. Wanner, Y.V. Yotov and T. Zylkin. 2019. Currency unions and trade: a PPML re-assessment with high-dimensional fixed effects. *Oxford Bulletin of Economics and Statistics* 81(3): 487-510.
- Maliszewska, M., A. Mattoo and D. Van der Mensbrugghe. 2020. *The potential impact of COVID-19 on GDP and trade: a preliminary assessment*. World Bank Policy Research Working Paper (9211). World Bank, Washington, DC, USA.
- Manners, P. and A. Behar. 2009. *Trade in Sub-Saharan Africa and opportunities for low-income countries*. World Bank, Washington, DC, USA. Available at: <https://openknowledge.worldbank.org/handle/10986/9242> License: CC BY 3.0 IGO.'
- McKibbin, W. and R. Fernando. 2021. The global macroeconomic impacts of COVID-19: seven scenarios. *Asian Economic Papers* 20(2): 1-30.
- Pingali, P. and R. Stringer. 2003. *Food security and agriculture in the low income, food-deficit countries: 10 years after the Uruguay round*. FAO, Rome, Italy.
- Silva, J.S. and S. Tenreyro. 2006. The log of gravity. *Review of Economics and Statistics* 88(4): 641-658.
- Sumner, A., C. Hoy and E. Ortiz-Juarez. 2020. *Estimates of the impact of COVID-19 on global poverty*. United Nations University World, Institute for Development Economics Research. <https://doi.org/10.35188/UNU-WIDER/2020/800-9>
- Swinnen, J. and J. McDermott. 2020. COVID-19 and global food security. *EuroChoices* 19(3): 26-33.
- United Nations. 2022. World food import bill to reach record high in 2021. November 11, 2021. Available at: <https://news.un.org/en/story/2021/11/1105552>
- U.S. International Trade Commission (USITC). 2022. Harmonized tariff schedule. USITC, Washington, DC, USA. Available at: <https://hts.usitc.gov/current>
- Van Berkum, S. 2021. How trade can drive inclusive and sustainable food system outcomes in food deficit low-income countries. *Food Security* 13(6): 1541-1554.
- Weidner, M. and T. Zylkin. 2021. Bias and consistency in three-way gravity models. *Journal of International Economics* 132: 103513.
- World Bank. 2022. World development indicators, and world governance indicators. World bank, Washington, DC, USA. Available at: <https://databank.worldbank.org/home>.
- Zajc Kejžar, K., A. Velić and J.P. Damijan. 2022. Covid-19, trade collapse and GVC linkages: European experience. *The World Economy* 45: 3475-3506. <https://doi.org/10.1111/twec.13314>