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Article

COVID-19 and changes in global agri-food trade

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Abstract

COVID-19 has raised questions about the resilience of agri-food trade to global shocks to the system. This paper analyses the changes in agri-food trade (values, extensive and intensive margin, and diversification) during the pandemic at global and regional levels. It also considers parallels in the changes in agri-food trade and changes of various COVID-19-related factors (infections, deaths, mobility, policy stringency, and industrial production output). The results show that changes in trade remained limited to short-term disruptions that mostly occurred at the extensive margin of trade and, primarily, at the height of policy stringency, mobility reductions, and the overall reduction of economic output. The trade of staples was most resilient, while that of other agri-food products declined considerably. Inter-regional trade of Asia, Africa, and Latin America and the Caribbean proved generally more resilient than these regions' intra-regional trade.

Keywords: COVID-19 pandemic, Agri-food trade, Extensive and intensive margin of trade, Trade diversification

JEL codes: F10, F14, Q17, Q18

1. Introduction

The rapid spread of the coronavirus disease 2019 (COVID-19) has increased morbidity and mortality rates worldwide. Countries implemented a multitude of policies to curb the spread of the virus and reduce the pressure on health systems. The pandemic's impact on public health, together with global mobility restrictions and macroeconomic impacts, has affected the supply, demand, and global trade of agri-food products. Trade policies were imposed to restrict imports and exports out of fear of contamination and to ensure the domestic availability of products, respectively. Meanwhile, trade-promoting policies, such as quota expansions and lowering non-tariff barriers, were implemented to counteract the negative impacts on food availability and access (FAO 2021a). The unprecedented shocks caused by the pandemic and the policy interventions have created concerns over the resilience of the global food system. Will countries depending on agri-food imports still be able to meet their import demand? Will agri-food exporters still be able to generate sufficient export earnings? In this regard, what is the role of the structure of global agri-food trade?

This paper analyses the changes in agri-food exports and imports and their level of diversification at global and regional levels during the first phase of the COVID-19 outbreak.

In this respect, the association of several pandemic-related factors with changes in different dimensions of the agri-food trade network is considered. Pandemic-related factors include changes in the infection rate, death rate, retail and workplace mobility measures, policy stringency, and induced macroeconomic factors. The consideration of different dimensions includes changes in total trade values and the distinction between changes in the intensive (trade values of existing trade links) and extensive (number of trade links) margins of trade. Furthermore, this paper considers the changes in trade diversification along the extensive and intensive margins and in terms of market and product portfolios.

COVID-19 has affected trade through multiple channels. The primary impact of COVID-19 on trade occurred when mortality and morbidity hit workers, leading to lower labour productivity (see e.g. Keogh-Brown et al. 2020; McKibbin and Fernando 2021) and thus reduced trade values and volumes. These effects are similar to those found for outbreaks of HIV/AIDS (Arndt and Lewis 2001), SARS (Lee and McKibbin 2012), the 2009 H1N1 epidemic (Dixon et al. 2010), and Ebola (World Bank 2014). The indirect effects of the COVID-19 pandemic included a range of containment and prevention measures. These measures resulted in policy-induced shocks on demand, such as the impact of restaurant closures (see e.g. Baldwin 2020; Brodeur et al. 2020; Lahcen et al. 2020; Roson and van der Vorst 2021), or supply, such as the impact of labour mobility restrictions (see e.g. Lahcen et al. 2020; Roson and Costa 2020) or both (Nechifor, Boysen et al. 2020; Nechifor, Ferrari et al. 2020; Nechifor et al. 2021). Trade is also affected when policies that restrict imports and exports are directly implemented at international borders (European Commission 2020a, 2020b; OECD 2020). The range of direct and indirect policy-induced impacts affects almost all segments of domestic and global value chains (GVCs) in the agri-food system. Moreover, the health impact of the pandemic and policy-related measures directly affect output, demand, and trade and can spill over to the economy and result in deepening the initial impacts. In this respect, the economic downturn in several epicentres of the pandemic (China, then Europe, then the United States) led to a steep decline in global demand and affected global trade (FAO 2021a; Laborde et al. 2021).

Countries participate in international trade to ensure or increase the availability and diversity of food products in their domestic markets and to generate income earnings from their exports. In food import-dependent countries, agri-food trade ensures people's access to food at reasonable prices and to provide a variety of different types of foods to enable healthy diets (FAO 2015). In export-dependent countries, trade shocks significantly influence agri-food producers' earnings (FAO 2015), particularly in developing countries, for which an important source of income is revenues from agri-food exports (FAO/UNCTAD 2017). The literature suggests that trade increases and economic development and sustainable outcomes are promoted through participation in agricultural GVCs (FAO 2020b). Nonetheless, the impact of shocks on agricultural and food exports and imports might differ depending on the role and degree of integration into global markets and GVCs (Koppenberg et al. 2021). Although strong integration in trade networks could potentially mitigate the impacts when only parts of the global system are affected, the effect on the entire network has been the concern of the emerging literature related to COVID-19.

Most attempts to shed light on the aforementioned concerns in the early literature were carried out using descriptive analysis to identify the short-term impacts or simulation analysis to project potential mid- and long-term impacts.[1] The main finding of this body of literature is that, despite uncertainties revolving around the continuation of the pandemic, the efforts of governments and agri-food sector stakeholders worldwide have helped keep food and agricultural trade flowing (Schmidhuber and Qiao 2020; Barichello 2021; Beckman and Countryman 2021; FAO 2021a; Hailu 2021).

To analyse the relevance of COVID-19 for the agri-food trade system, this paper examines the changes in a set of trade indicators and diversification measures. The primary focus is on the first wave of COVID-19 (i.e. first half of 2020 relative to the equivalent monthly averages of 2018 and 2019), during which the most significant changes in agricultural and food trade values are observed. The analysis is based on monthly trade data of 96 countries at the HS 6-digit commodity level. The trade indicators considered in this study are trade values, trade links, and various trade diversification measures, such as the Theil, Gini, and Herfindahl indices showing the distribution of trade values across trade links. Moreover, the Theil index is decomposed to obtain information on changes in the distribution along the extensive and intensive margins of trade. The Herfindahl index is also modified to distinguish between product and market diversification. In addition, a correlation analysis is applied to test the association of pandemic-related factors (infection rate, death rate, retail and workplace mobility measures, policy stringency, and induced macroeconomic factors) with changes in trade values and diversification at the country level.

This paper contributes to the literature in three ways. First, this paper analyses changes in the trade system during the first wave of COVID-19 in terms of both the extensive and intensive margins of trade and the diversification of trade flows along both margins. Second, this paper investigates monthly changes in the agri-food trade network at both global and regional levels and across product groups. Third, this paper analyses the association of pandemic-related factors with changes in the trade system in terms of both values and the distribution of values across trade links.

This paper is organized as follows. The next section summarizes some key features of the COVID-19 outbreak and discusses different impact channels on agri-food trade. Specific research questions are derived using this background information. Next, the approach and data for calculating the trade indicators and diversification measures are presented. Then, the results are presented and the final section concludes.

2. Background and derived research questions

On 31 December 2019, the World Health Organization (WHO) was informed of pneumonia cases with an unknown cause in Wuhan City, China. On 7 January 2020, Chinese authorities recognized as the cause of the disease a novel coronavirus that previously had not been identified in humans. On 11 March 2020, following its rapid spread outside China, the WHO declared the outbreak of COVID-19 as a pandemic (WHO 2020a, 2020b). The pandemic significantly affected health systems and resulted in the formulation of various containment measures that, in turn, reduced economic activities and resulted in reduced economic activity and affected the global trade system.

2.1 Morbidity and mortality rates

Changes in mortality and morbidity rates are factors that can interrupt the trade network. Mortality and morbidity rates directly affect labour availability. Since the outbreak of the pandemic, infection and mortality rates increased significantly since March 2020 (Panel A of Fig. 1). The increased morbidity reduced labour productivity (Bochtis et al. 2020; Petrov et al. 2021) that, in turn, resulted in a supply decrease.[2]

2.2 Policy responses

In response to COVID-19's direct health impacts, virus containment measures were first imposed during the first half of the year, particularly, from March to June 2020. As shown in Panel B of Fig. 1, policy stringency as reflected by the Oxford Stringency Index increased, and workplace and retail mobility rates as measured by Google Mobility indices declined substantially from March to June.

The measures implemented to curb the circulation of the virus had disruptive effects on the value chains of many products, including on agri-food markets (Hale et al. 2020; Laborde et al. 2021). On the supply side, measures such as border closures and mobility

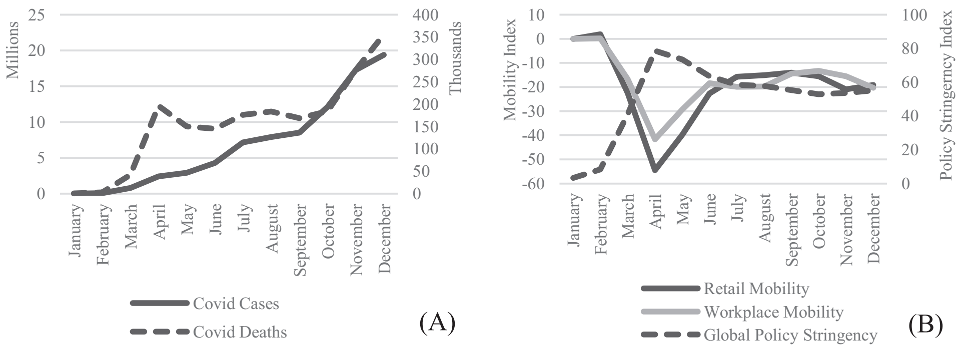

Figure 1. Evolution of global COVID-19 indicators and related factors.
Source: Own calculations based on data from John Hopkins University (Dong et al. 2020; JHU 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford 2021), and Google Mobility indices (Google 2021).
Remark: The mobility index is normalized with respect to its value in the base month of January 2020.

restrictions led to shortages in labour, which, together with shutdowns and (partial) business closures, affected the availability of inputs, agricultural production, food industry, and the distribution of products in domestic and international markets (Bochtis et al. 2020; Larue 2020; Schmidhuber et al. 2020). To counteract supply chain disruptions, countries provided logistics and marketing support, direct transfers and loans to producers and traders (FAO 2021a). On the demand side, reduced incomes, restrictions on the movement of people, fear of infection, and widespread closures of the hospitality sector induced immediate changes in consumption patterns (Cranfield 2020; Hobbs 2020; FAO 2020a; Goolsbee and Syverson 2021; Hailu 2021).

Countries imposed a range of trade policy measures to mitigate the impacts of the pandemic and the measures to contain it on food security and food safety (see FAO 2021a). On the one hand, several countries restricted exports to ensure the domestic availability of food, particularly during the second quarter of 2020. Import restrictions, sanitary, and phytosanitary measures and additional certification requirements were applied to contain possible virus transmission through food imports. Both export and import restrictions implied direct trade disruptions. The measures also induced indirect impacts on GVCs for which traded commodities served as intermediate inputs in more downstream value chain segments. On the other hand, many countries committed to refrain from trade-restricting measures to alleviate supply chain disruptions and ensure global food security. Some exporters lowered export duties or implemented airfreight assistance programmes to support their traders in overcoming transportation and logistics disruptions. Several countries lowered import tariffs and adopted trade facilitating practices, such as the digitalization of trade-related procedures, simplified import-licensing procedures, and the establishment of green corridors to accelerate the delivery of selected food products (FAO 2021a).

Both domestic and trade measures affected trade values and the distribution of trade values noticeably across countries and products. Indeed, Arita et al. (2022) show strong impacts of policy restrictions and reduced human mobility rates on agri-food trade, whereas the effects of morbidity and mortality rates remained limited.

2.3 Macroeconomic factors and food prices

The direct health impacts and policy responses have resulted in a downturn in economic activity products, which affected the trade network (Vickers et al. 2020). Global GDP in 2020 declined by 3.41% year-on-year (World Bank 2021). Global industrial economic

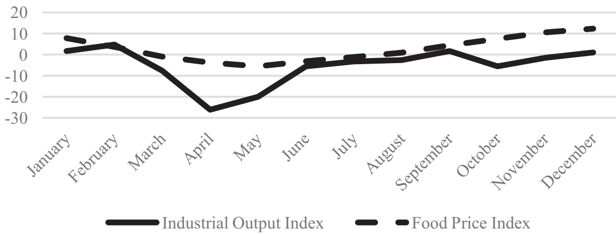

Figure 2. Global industrial output and food prices (percentage change compared with 2018/19). Source: Own calculations based on the Monthly Index of Industrial Production (UNIDO 2021) and the Food Price Index (FAO 2021b).

output started to decline in March (when it was 15% lower than its same month average in 2018 and 2019) and further reduced in April to approximately –25% of the same monthly average value (see Fig. 2). In May, industrial output started to rebound but remained far below its 2018/2019 average (−20%). In June, industrial output rebounded to 5% less than its average monthly value. Thereafter, changes in industrial output remained within the range of −5% and +1% of the same monthly averages of previous years. These changes reflect the changes in mobility constraints and policy stringency, as given in Panel B of Fig. 1. Global industrial output is negatively correlated with policy stringency ($r = -.61$, $p < .0001$, $n = 358$) and positively correlated with mobility measures; the lower the retail and workforce mobility, the lower the economic output (retail mobility: $r = .70$, $p < .0001$, $n = 337$; work mobility: $r = .66$, $p < .0001$, $n = 337$).

Along with the reduction in global industrial output, global food prices also decreased (Fig. 2; Elleby et al. 2020), albeit this reduction in prices was less than that of industrial commodity prices, mainly due to lower income elasticities (World Bank 2020). Food prices reacted differently at the commodity level because of differences in demand and supply responses, which reflect differences in policies and expectations related to individual commodities, types of products (such as perishability and storability), income elasticities, etc. For example, the prices of agricultural products that have stronger linkages with the demand for industrial goods, such as rubber, cotton, vegetable oils, and sugar cane dropped more significantly than the prices of products with weak linkages to industrial demand such as meat and dairy products (FAO 2021a). These heterogeneous price responses at the commodity level led to differential price impacts across countries, because countries trade different bundles of commodities.[3]

The pandemic and related policy measures were also associated with changes in other macroeconomic factors including exchange rates (Gen-Fu et al. 2021). As countries export and import different bundles of products and changes in trade across products were not uniform, the ratio of export and import value changes resulted in shifts in the relative demand for and supply of currencies.

The changes in economic output, price and exchange rate, in turn, affected trade. The simultaneous changes of these macroeconomic variables and trade are the result of the interaction of a multitude of supply and demand side factors. Given the purpose of this analysis, that is, to describe changes in agri-food trade and draw parallels between trade and COVID-19 related measures, the quantification of the causal relationships is beyond the scope of this paper.

2.4 Empirics of COVID-19 and agri-food trade

Given the simultaneity and multitude of the impacts, the empirical literature generally does not distinguish between changes in these factors individually and their association with changes in agri-food trade but, rather, focuses on the assessment of the collective impact of

COVID-19. An exception is a study by Arita et al. (2022), who econometrically show that an increase in COVID-19 incidence rates, governmental policy restrictions and declining human mobility led to reductions in agricultural trade in a range of 5 to 10%. Overall, few studies analyse the relevance of the pandemic for agri-food trade. Most of these studies rely on descriptive statistical methods and find only short-lived impacts, which are consistent with the peak of the policy measures and the short-term application of countries' trade restrictions.

The studies find that the decline in trade in non-agricultural sectors was generally more significant than the reduction in agri-food trade (WTO 2020, 2021; Arita et al. 2022). Arita et al. (2022) show that trade in both agricultural and non-agricultural products decreased in the second quarter of 2020 by approximately 2 and 18%, respectively.[4] The recovery of trade in subsequent quarters resulted in annual percentage changes of +3.5% for agricultural and −6% for non-agricultural products compared with the year before.[5] Thus, agri-food trade seems to have been more resilient compared with trade in non-agricultural sectors, whereas staple food product trade was more resilient than trade in non-staples against the shock.[6] In addition, the authors show that trade for least developed and low-income countries was most vulnerable to the shocks.

Beckman and Countryman (2021) find a total increase in global agricultural trade value of 2.3% in 2020 compared with 2019 but heterogeneous impacts across commodity groups. They show that the trade values of major food products (e.g. coarse grains, sugar, and oilseeds) increased, whereas trade of other products, such as beverages, tobacco, and plant-fibres, experienced reductions of more than 10%.

Similarly, Schmidhuber and Qiao (2020) show changes in biannual agri-food trade from 2019 to 2020 (0.8% increase in the first six months) and conclude that global food markets are resilient to COVID-19 shocks. In particular, the authors find a limited impact on staple foodstuffs (changes up to +11.2% for oilseeds and oleaginous fruits) and some food products important for a healthy diet, such as fruits and vegetables (2.5%).

Vickers et al. (2020) examine the impacts of COVID-19 on the food trade of Commonwealth countries and argue that national lockdowns affected domestic economic activities and trade logistics. These lockdowns also reduced the Commonwealth's exports between February and May 2020 relative to the same monthly averages for 2018 and 2019. However, exports from African Commonwealth countries decreased only in May 2020 following a subsequent introduction of lockdown measures in these countries.

Barichello (2021) shows that the pandemic's impact on Canadian agricultural trade in 2020 (year-on-year increase of 11%) differed substantially from the expected impact at the beginning of the pandemic (decline of 12% to 20%). Consistent with this finding, Hailu (2021) also shows that the pandemic hit Canadian food exports in April and May 2020; however, thereafter, exports were higher than in the same months in 2019.

Based on combined CGE and household model simulations, Laborde et al. (2021) project a decline in global trade from both demand and supply-side effects. Elleby et al. (2020) employ a recursive dynamic partial equilibrium model (Aglink–Cosimo) and project that the rather inelastic nature of food consumption toward prices would prevent a sharp decline in agri-food trade.

2.5 Specific research questions

Based on the discussion of individual impact channels and the evidence found in the literature, we derive several specific research questions (RQs). The first question (RQ1) is whether increased morbidity and mortality rates induced policy responses, and macroeconomic impacts are significantly related to changes in trade values. Subsequent questions simultaneously consider the channels. The following questions are asked: (RQ2) What are the direction and the magnitude of the changes in global trade values during COVID-19?

(RQ3) How does the impact on trade values differ across regions and commodities? (RQ4) What are the changes in the extensive and intensive margin of trade at global and regional levels during the pandemic? (RQ5) Are there changes in the net trade position of the different regions? (RQ6) Are there differences in the changes in the inter- and intra-regional trade values? Moreover, we consider several questions regarding the diversification of the agri-food trade and question (RQ7) the relationship between individual impact channels with trade diversification. (RQ8) What are the changes in the diversification of the trade system globally, regionally, and across commodities? (RQ9) Are there differences in the diversification along the extensive and intensive margins of trade? Finally, we ask (RQ10) whether changes in trade diversification occur more along market or product diversification.

3. Empirical approach and data

To answer the questions, we examine a set of export and import trade indicators and diversification measures at the global, regional, and commodity levels. We calculate the indicators and measures for the first half of 2020 on a monthly basis and compare them to the same monthly averages of 2018 and 2019.[7] Moreover, we run a correlation analysis to examine the relations of the individual indicators of COVID-19 with the changes in agri-food import values and import diversification measures.

We consider three trade indicators, namely percentage change in trade values, percentage change in the number of active trade links, and absolute values of the regional agri-food net trade positions. The percentage changes in monthly import and export trade values reflect the overall changes in trade during the pandemic compared to the pre-pandemic period. The percentage changes in the number of active trade links (i.e. the number of exporting and importing country pairs per HS six-digit product level for each month) denote the changes in the extensive margin of trade. We use information on the changes in total trade value and the extensive trade margin to deduce changes in the intensive margin of trade. The total trade value Q as the product of the number of trade links N (i.e. the extensive margin of trade) times the average of the trade values per trade link q (i.e. intensive margin of trade) results in $Q = Nq$. Therefore, we can infer the intensive margin of trade q from the changes in total trade values Q and the changes in the extensive margin of trade N.[8]

We also compare the net agri-food trade position at a regional level before and during the pandemic. This indicator is defined as the regional trade balance (export minus import value) over the trade value (sum of export and import values) and varies between -1 and 1. A positive number indicates net exporting regions, and a negative number indicates net importing regions. The higher the index, the stronger the position of the region towards having a positive trade balance.

We further use three diversification/concentration measures (hereafter called diversification measures) before and after the pandemic. These diversification measures include the Theil index, the Gini index, and the Herfindahl index and are applied to measure both import and export diversification. We present the calculation of the import diversification measures but skip the presentation of the export diversification measures because they are analogous to the import side diversification measures.

The Theil index measures the inequality of trade values across trade links based on the maximum possible entropy of the data (i.e. complete equality in the distribution) and the observed entropy and ranges from zero to an infinite number. A higher Theil index shows greater inequality. We follow the reasoning of Cadot et al. (2011) and calculate the Theil entropy index to measure the diversification of trade values across trade links. We then attribute the total Theil index to the within-group components that show diversification along the intensive margin of trade and the between-group components that show diversification along the extensive margin of trade. The change in the diversification along the extensive margin of trade refers to the change in the number of active trade links by each commodity and each source of imports. The change in diversification along the intensive margin of trade refers to the change in the equality of the import values across the existing trade links. The Theil index $T_{i,m,t}$ as an overall diversification measure for product i in importing country m in year t is calculated as[9]

$$T_{i,m,t} = \frac{1}{N_{i,m,t}} \sum_{x=1}^{N_{i,m,t}} \frac{V_{i,m,t,x}}{\mu_{,i,m,t}} \ln\left(\frac{V_{i,m,t,x}}{\mu_{i,m,t}}\right), \tag{1}$$

where $\mu_{i,m,t} = \frac{1}{N_{i,m,t}} \sum_{x=1}^{N_{i,m,t}} V_{i,m,t,x}$. Considering that each trade link refers to the trade value of commodity i imported by country m from country x in year t, the trade value occurring at each trade link is defined as $V_{i,m,t,x}$. Additionally, $N_{i,m,t}$ refers to the number of trade links available for an importing country.

The decomposition of the total Theil index ($T_{i,m,t}$) into the within-group ($T^{W}_{i,m,t}$) and between-group ($T^{B}_{i,m,t}$) components ensures that:

$$T_{i,m,t} = T^{W}_{i,m,t} + T^{B}_{i,m,t}. \tag{2}$$

The between-group Theil index is defined as follows:

$$T^{B}_{i,m,t} = \sum_{g=0}^{1} \frac{N^{g}_{i,m,t}}{N_{i,m,t}} \frac{\mu^{g}_{i,m,t}}{\mu_{i,m,t}} \ln\left(\frac{\mu^{g}_{i,m,t}}{\mu_{i,m,t}}\right). \tag{3}$$

The superscript g refers to each group of observations zero and non-zero. $N^{g}_{i,m,t}$ is the number of import links in group g and $\mu^{g}_{i,m,t}$ is the average trade value.

The within-group Theil index is defined as:

$$T^{W}_{i,m,t} = \sum_{g=0}^{1} \frac{N^{g}_{i,m,t}}{N_{i,m,t}} \frac{\mu^{g}_{i,m,t}}{\mu_{i,m,t}} \left[\frac{1}{N^{g}_{i,m,t}} \sum_{x\in g} \frac{V^{g}_{i,m,t,x}}{\mu^{g}_{i,m,t}} \ln\left(\frac{V^{g}_{i,m,t,x}}{\mu^{g}_{i,m,t}}\right)\right]. \tag{4}$$

The Gini index as an alternative measure to the Theil index shows the extent of inequality in trade values across different import links, that is, the diversification of import values across different trade links. It ranges between zero, which indicates complete equality, and one, which indicates complete inequality in import shares across different import links. Following Jaimovich (2012), we calculate the Gini index using

$$Gini_{i,m,t} = 2\frac{\sum_{x=1}^{N_{i,t}} X\, V_{i,m,t,x}}{N_{i,t} \sum_{x=1}^{N_{i,t}} V_{i,m,t,x}} - \frac{1 + N_{i,t}}{N_{i,t}}. \tag{5}$$

$Gini_{i,m,t}$ is the value of the Gini index for imports of commodity i by importer m for year t. Each exporter x is numerically ordered according to its value of exports of i to m during t, from smallest to highest, including zero trade flows. The variable X refers to the numerical order.

Lastly, the Herfindahl index also shows the concentration of import shares across the spectrum of agricultural and food imports. It is defined as the sum of the squares of the import shares across import links and is normalized by subtracting $\frac{1}{N}$ and dividing by $(1 - \frac{1}{N})$, where N refers to the number of active import links. The normalization ensures that the index ranges from zero to one. A larger index value is associated with greater concentration. An index value of zero indicates high diversification across numerous trade links, and the index value of one indicates the complete concentration in one import link. We follow Jaimovich (2012) and define the value of the normalized Herfindahl index of import shares of commodity i by importer m in year t as:

$$H_{i,m,t} = \frac{\sum_{x=1}^{N_{i,t}} (S_{i,m,t,x})^2 - \frac{1}{N_{i,t}}}{1 - \frac{1}{N_{i,t}}}, \text{ where } S_{i,m,t,x} = \frac{V_{i,m,t,x}}{\sum_{x=1}^{N_{i,t}} V_{i,m,t,x}}. \quad (6)$$

$N_{i,t}$ is the total number of active exporters of i during t. An active exporter of i during t is a country that has exported a strictly positive amount of goods i at least to one importer during year t. This index shows the overall concentration along both markets and products. A modification also allows for separately calculating the diversification for both dimensions. Removing subscript m from the previous formula results in a product diversification measure. Removing subscript i results in a market diversification measure. Market diversification refers to the diversification of import shares across trading partners regardless of the diversity of the product groups from each trading partner and to how a country's imports across all import sources differ from a uniform distribution; that is, it shows how import shares from different sources vary. In contrast, the product diversification measure refers to the diversification of import shares across the commodities regardless of the source country.

We calculate the aforementioned indicators and measures using monthly trade values from Trade Data Monitor (TDM) at the HS6 level for ninety-six countries up to June 2020. TDM gathers monthly export and import statistics from statistics institutes, customs agencies, and other sources. Trade values are given in USD. In our analysis, we include all HS6 level commodities belonging to agri-food commodity groups following Annex 1 of the WTO Agreement on Agriculture (AoA) plus fishery products (see Table A.1 for detailed information on the commodities considered). The analysis covers twenty-two countries in Asia, fourty countries in Europe, seventeen countries in Latin America and the Caribbean, two countries in Northern Africa, two countries in Northern America, two countries in Oceania and, eleven countries in sub-Saharan Africa (see Table A.2 for the country coverage).

At the global level, we analyse changes in both the imports and exports of the ninety-six sample countries to/from all countries. For the correlation analyses, we use country level data on incidence and mortality numbers provided by John Hopkins University, the Oxford Stringency Index, Google's Community Mobility Reports, and the UNIDO Index of Industrial Production (Blavatnik School of Government, University of Oxford 2021; Google 2021; JHU 2021; UNIDO 2021).

4. Results and discussion

4.1 Trade values

The changes in the trade values at the global level suggest short-term disruptions during the pandemic. As shown in Fig. 3, in January 2020, global import values declined by 2.0%, followed by an increase in February (4.5%).[10] In March, global import values increased by 2.2% compared with previous years. In general, no trade reduction was observed in the first quarter of 2020. Nonetheless, our analysis does not exclude the possibility that trade on a global level could have been higher in the absence of COVID-19. Widespread virus containment policies adopted by most countries mainly started during the second half of March 2020 when mortality and morbidity rates increased more strongly (FAO 2021a; see also Fig. 1). Global movement restrictions to contain the spread of the virus peaked in the following two months (Panel B of Fig. 1), when we observe a downturn in economic activity (Fig. 2) and a decline in import values in April (−5.5%) and even more significantly in May (−10.0%). Thereafter, in June 2020 and in parallel with a relaxation of global movement restrictions and the recovery of the global economy, global import values rebounded and increased by 4.8% compared with the average import value of June 2018/2019. The changes in export values display a similar pattern as import values (Fig. 3).[11]

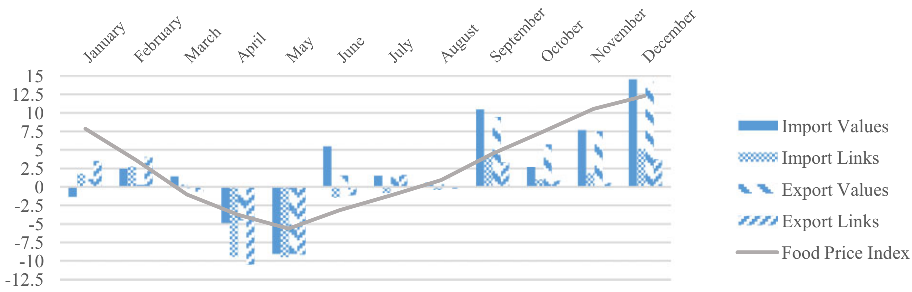

Figure 3. Global changes in trade indicators (percentage change compared with 2018/19).
Source: Own calculations based on data from TDM and the Food Price Index (FAO 2021b).

Both containment measures and global economic activity are significantly correlated with import values. When policy stringency reaches its highest level, workplace as well as retail mobility are at their lowest levels, and industrial output and agri-food trade values decline. Fig. 4 shows the correlations of the COVID-19 related factors with changes in import values. Policy stringency and changes in trade values are significantly, albeit weakly, negatively correlated ($r = -.22$). Both workplace and retail mobility are weakly positively correlated with changes in import values (with correlation coefficients of 0.24 and 0.23, respectively). A stronger association ($r = .38$) is found between the change in import value and the level of industrial production output. No significant correlation exists between changes in import value and the numbers of COVID-19 cases and related deaths. Similar correlations (not reported here) are found for the export value changes with the measures of global economic activity and policy restrictions. Thus, considering RQ1, we conclude that morbidity and mortality rates are not significantly related to changes in import value, whereas induced policy responses to the pandemic and macroeconomic impacts show associations with changes in trade values.

With respect to RQ2, we find that global trade values declined at the beginning of the COVID-19 pandemic relative to pre-pandemic levels, particularly in April and May 2020. Changes in trade values are associated with changes in both trade volume and price. A significant drop in food prices was observed between March and May 2020 (Fig. 3), which suggests that part of the reduction in trade values may reflect declining prices. However, percentage decreases in prices are generally lower than that of import values in April and May, suggesting decreases in trade volumes.

Comparing changes by product groups, non-food commodities were relatively more affected than foods (Fig. A.2). Import values of cotton declined by almost 30 and 50% in April and May, respectively. The main reason for this strong decline appears to have been reduced demand for downstream products that use cotton as an intermediate input (Muhammad et al. 2021; Voora et al. 2021). Significant declines are also evident on import values of products such as live animals (−18% in April, −14% in May), live plants and cut flowers (−28%, −14%), and tobacco (−12%, −21%), which were induced by logistical bottlenecks, reduced demand and, partly, policy restrictions (Morton 2020; Saha and Bhattacharya 2020).

Among food products, trade values of staples and other essential foods were least affected. They only decreased in May, with reductions ranging from −1% (fruits and nuts) to −4% (vegetables). In contrast, fish (−21%, −22%) and beverage (−16%, −25%) import values declined considerably, probably related to virus containment measures such as the closure of restaurants and restrictions on social events (Eftimov et al. 2020; FAO 2020a). Import values of most product groups recovered in June but still remained lower than the average level of 2018/19 for beverages (−11%), fish (−7%), live animals (−5%) and, noticeably, cotton (−39%).

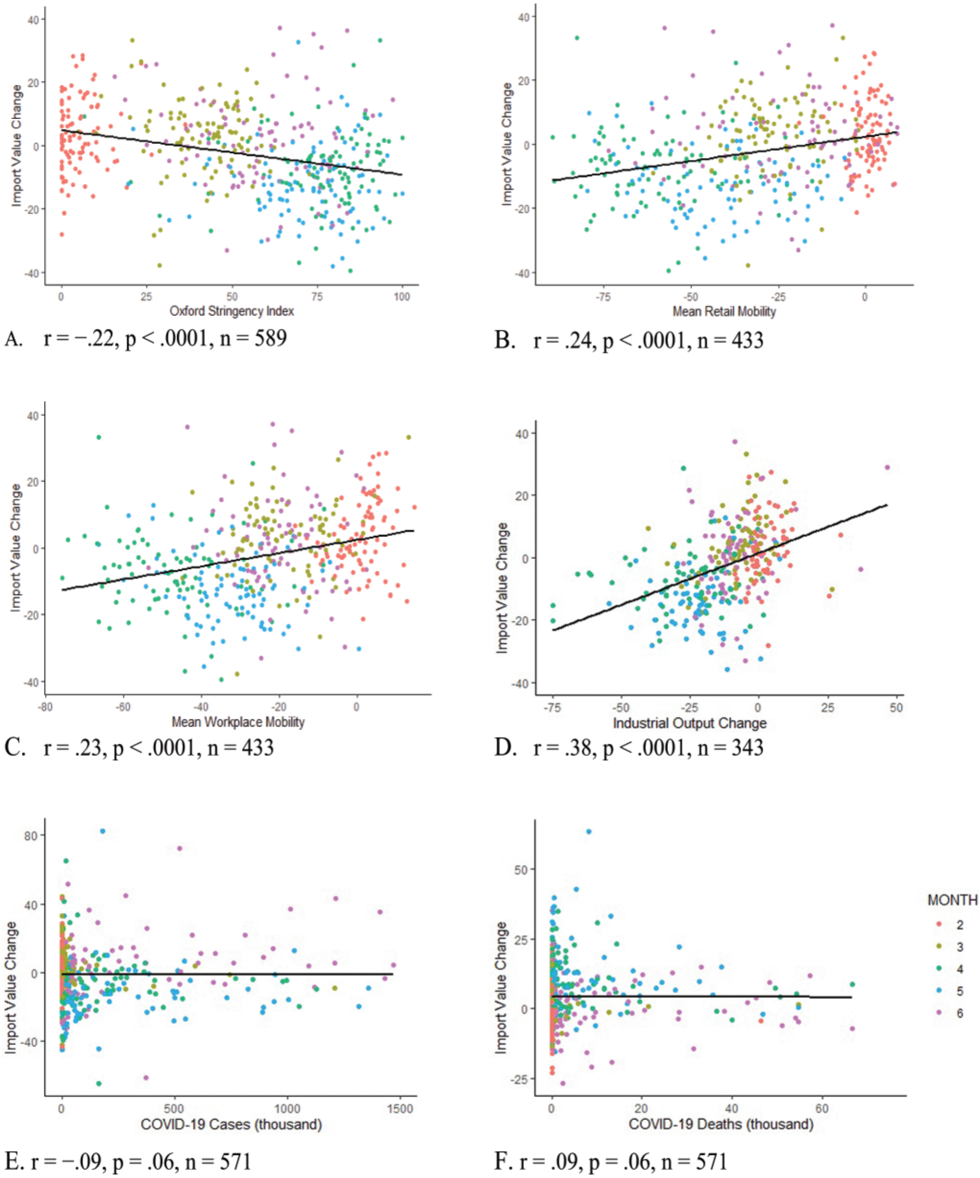

Figure 4. Correlations of import value (percentage change) with containment measure indicators (indices) and industrial production output (percentage change).
Source: Own calculations based on data from TDM, John Hopkins University (Dong et al. 2020; JHU 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford 2021), Google Mobility indices (Google 2021), and the Monthly Index of Industrial Production (UNIDO 2021).

At the regional level, mixed developments of import values are observed during the first quarter of 2020; however, similar to the global level, most regions show reduced imports in April and May (Fig. 5). In June, import values generally rebounded.

Only the import values in sub-Saharan Africa and Latin America and the Caribbean remained lower than the monthly averages of previous years by 13 and 4%. One reason for the

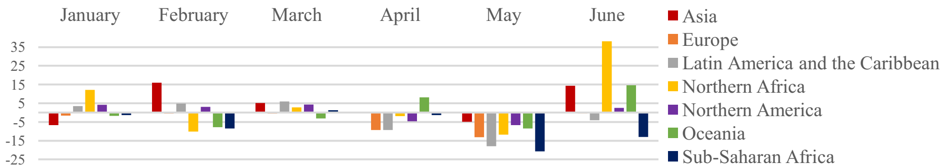

Figure 5. Import value changes at regional level (per cent).
Source: Own calculations based on data from TDM.

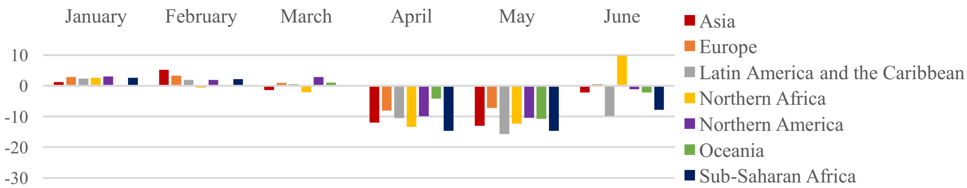

Figure 6. Changes in the number of active import links on a regional level (per cent).
Source: Own calculations based on data from TDM.

delayed impact in the sub-Saharan region could be that, given delayed soaring of COVID-19 infections, virus containment and trade-restricting measures in this region took place slightly after other regions (UN 2021). In Latin America—a major net exporting region—the reduction in import values in absolute terms was relatively low.

On the export side, all regions except for Latin America and the Caribbean experienced a reduction in their exports between March and May 2020 (Fig. A.1). Some of the major agricultural exporters are located in Latin America and the Caribbean and might have acted as a buffer to mitigate the negative impact on the imports of their partner countries. One driver of this development is China's increased import demand for oilseeds and grains from Brazil and Argentina (Schmidhuber and Qiao 2020). In June, mixed results are observed for export recovery.

Based on these findings and in accordance with RQ3, we state that non-food commodities experienced significant reductions compared with foods, whereby many staples were least affected. Changes in the trade values across regions were mixed, but most regions experienced a decrease in their imports and exports.

4.2 Extensive and intensive margins of trade

Percentage changes in the number of active trade links—denoting the extensive margin of trade—reveal sharp reductions in April and May 2020 (Fig. 6). During these months, the decrease in the extensive import (export) margin at the global level was 9.3 and 9.4% (11.1 and 10.1%), respectively.

The change in the extensive margin of trade in April and May 2020 (Fig. 6) was more pronounced than the change in the overall trade values (Fig. 5). This finding indicates that changes in trade values are mainly derived by a reduction in trade links and less by changes in the intensive margin of trade. The data also suggest that the reduction in trade links was, in part, even counteracted by increasing intensity of trade in the remaining trade links. In June, the number of trade links still remains slightly lower than the 2018/19 average, whereas overall trade values rebounded, suggesting increases in the intensive margin of trade (i.e. the average trade values per link).

Across regions, we notice similar patterns of change in the extensive margin of imports at the global level that reflect changes in the number of varieties available to consumers in terms of products and origins. In April and May in all regions, reductions range from −4.2% in Oceania (in April) to −15.7% in Latin America and the Caribbean (in May).

In June, the extensive margin of imports increased again in Europe and Northern Africa, whereas the other regions continued to record subdued numbers of trade links. Additionally, at the regional level, the decline in the extensive margin of imports is more pronounced than the decline in import values, implying that the reduction in import values in April and May mainly stem from reduced numbers of trade links. In Asia, the percentage change in the total import value in April is negligible, whereas a reduction of 13.0% in the extensive margin of imports is observed (Fig. 6). This finding implies that an increase in the intensive margin of trade outweighed the decline in the extensive margin of trade. A similar pattern is found in June when total import values of most regions increased, but the extensive margin of imports was still depressed.

Moreover, we observe a decline in the extensive margin of exports in all regions from March to June, with the exception of Latin America and the Caribbean, for which the number of export links increased (Fig. A.3). In June, the number of export links is still lower than in 2018/19 but on an upwards trend compared with the previous months. Export values increased already in June, indicating that disruptions in the export links were compensated through higher trade intensity in the remaining links at the global level.

Linking these findings to RQ4, we summarize that agri-food trade declined mainly in the extensive margin at the global level and in most regions in April and May. Only in Latin America and the Caribbean did the number of export links increase throughout all months relative to previous years.

4.3 Net trade positions

The changes in import and export values led to changes in the net (agri-food) trade positions at the regional level, as shown in Fig. A.4. Asia and Northern Africa are, on aggregate, net importing regions of agri-food products throughout the period under investigation and deepened their position as net importers at the beginning of the pandemic. Latin America and the Caribbean and Oceania remained, on aggregate, net exporting regions during the pandemic. The former region had a more pronounced export position compared with the pre-pandemic period, suggesting this region's important role in alleviating severe reductions in the imports of some other regions, whereas net exports of the latter region weakened but remained positive. Considering the limited country coverage in sub-Saharan Africa in this study, this region also shows a positive and deepening net export position.[12] In May 2020, Europe changed its position from a net exporter to a net importer. Northern America shows a tendency to turn from a net exporting to a net importing region during the observed months in 2020 relative to 2018/19. However, when considering only the monthly net trade positions of 2019, Northern America is observed to already have been a net importer in April and May 2019.

In view of RQ5, changes in the net trade positions are generally small. The effects can also be mixed because regional net trade positions are often driven by a few major importers or exporters. Moreover, the limited country coverage of some regions must be considered when evaluating the regional net trade positions.

4.4 Intra- and inter-regional trade values

Next, we investigate the changes in inter- and intra-regional trade during the first months of the pandemic. Generally, intra-regional import links declined more intensely than inter-regional import links (see Figs. 7 and 8), but the pattern differs across regions. In sub-Saharan Africa, a region with many developing countries that mainly export a limited range of agricultural raw materials to global markets and import foods from global markets, inter-regional trade links experienced less disruptions than trade links with countries within the region. Europe and Northern America, with a majority of high-income countries and strong market integration, show higher resilience of intra-regional trade (FAO 2020b,

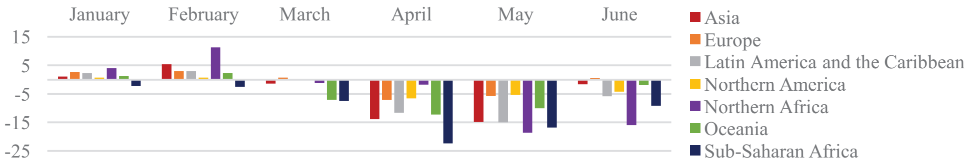

Figure 7. Changes in the number of active links of intra-regional imports (per cent).
Source: Own calculations based on data from TDM.

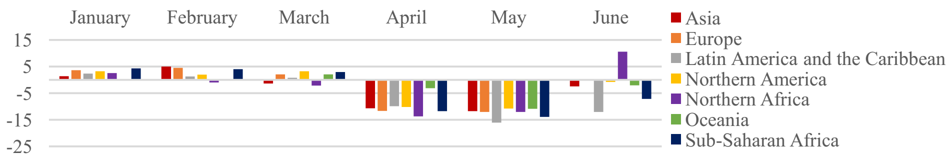

Figure 8. Changes in the number of active links of inter-regional imports (per cent).
Source: Own calculations based on data from TDM.

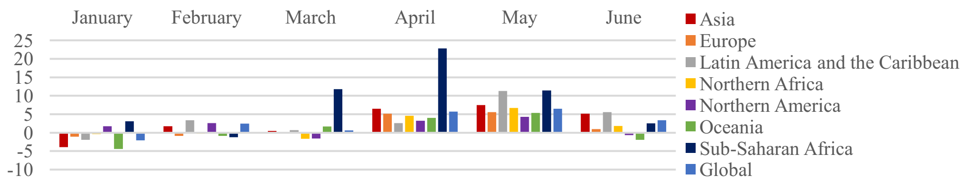

Figure 9. Changes in the Theil index of imports on global and regional levels (per cent).
Source: Own calculations based on data from TDM.

2021a). Intra-Asian trade also decreased more intensely than Asian countries' inter-regional trade. Figs. A.5 and A.6 show the changes in intra- and inter-regional import values.

Given RQ6, the data suggest an association between the role of inter- and intra-regional trade of available food varieties in terms of the number of products and product origins and regions' stages of development and level of integration in global and regional markets. Given a higher level of development and regional integration, intra-regional trade proved more resilient than trade with other regions. The reverse holds for regions with a majority of countries at lower development stages.

4.5 Diversification of trade system

Import diversification as measured by the percentage changes in the Theil index is presented in Fig. 9. Compared with the pre-pandemic period, the import diversification at a global level decreased (i.e. the Theil index increased) by approximately 6% in April and May and by 3.3% in June.[13]

Policy stringency (r = .41), retail (r = −.46) and workplace mobility (r = −.41) and industrial output changes (r = −.49) are significantly correlated with the percentage changes in the level of import diversification (Fig. 10). These correlations are somewhat stronger than the association of these variables with trade values.

With respect to RQ7, we conclude that stringer policy restrictions, lower industrial output, workplace, and retail mobility are correlated with higher concentrations of countries' imports. However, we observe no significant correlations of case and death rates with import diversifications.

We find significant declines in import diversification (increases in the Theil index) for almost all commodity groups during April and May 2020, except for some staple foods, such as oilseeds (increase in April) and cereals (increase in all considered periods). Generally,

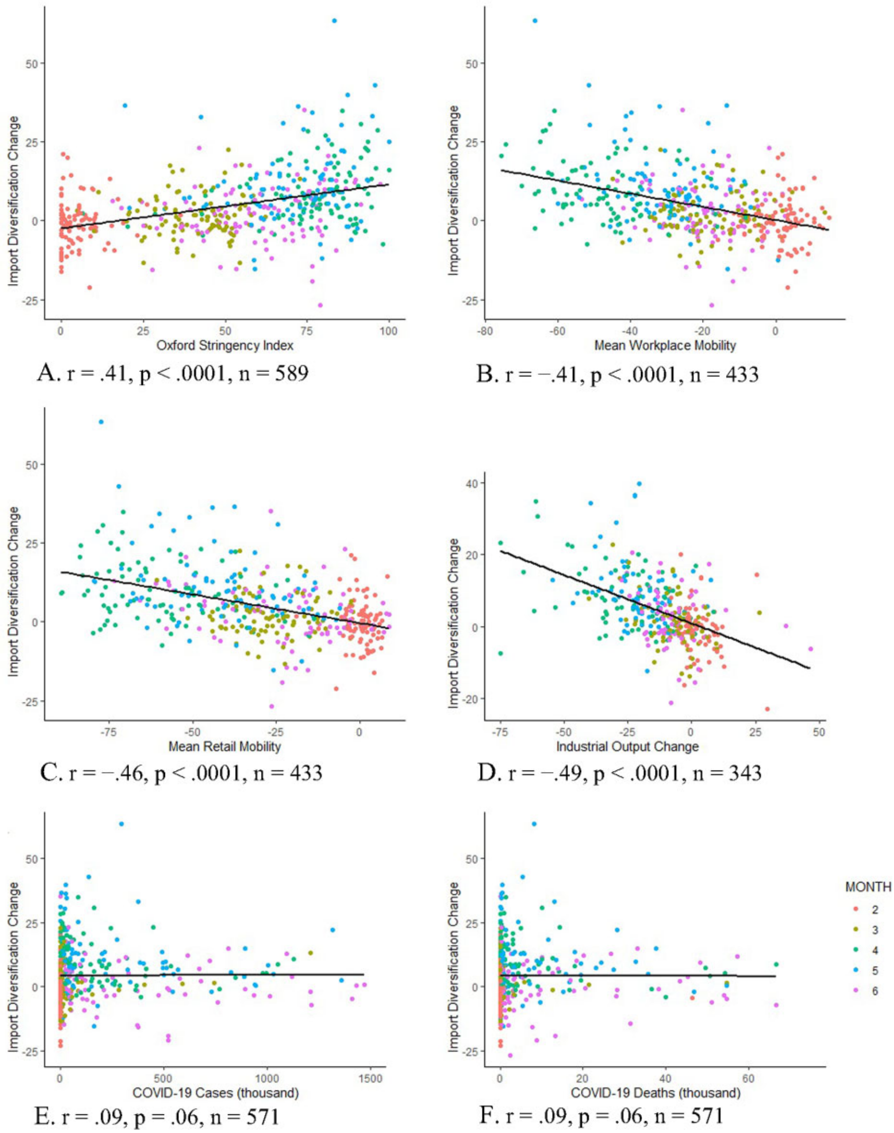

Figure 10. Correlations of import diversification (percentage change) with containment measures indicators (indices) and the global economic activity (percentage change).
Source: Own calculations based on data from TDM, John Hopkins University (Dong et al. 2020; JHU 2021), Oxford Stringency Index (Blavatnik School of Government, University of Oxford 2021), Google Mobility indices (Google 2021), and Monthly Index of Industrial Production (UNIDO 2021).

the diversification of staple foods has shown weaker deterioration than for non-staple foods. The meat sector experienced the most noticeable concentration of import shares across trade links during the considered periods (range from 6 to 18%; see Fig. A.7 for more detail at product level).

The results at the regional level (Fig. 9) reveal similar patterns of change towards less diversification as at the global level. The most significant decline in import diversification is observed in sub-Saharan Africa, where trade diversification as measured by the Theil index diminished by 12, 23, and 12% in April, May, and June, respectively. Import

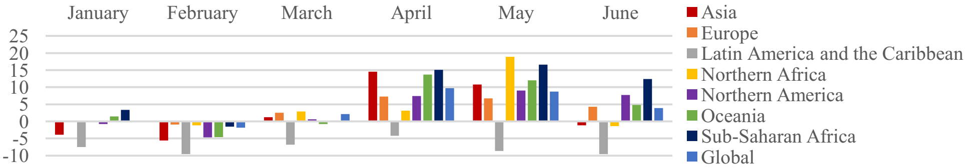

Figure 11. Changes in the Theil index of exports on global and regional levels (per cent).
Source: Own calculations based on data from TDM.

diversification remained lower than in previous years from April to June also in Asia, Europe, Latin America, and the Caribbean and Northern Africa. Northern America and Oceania experienced declining diversification rates in only April and May but not June 2020.

We apply the Theil index to exports and find that the diversification of export values across trade links also decreased significantly at both global and regional levels in April and May (Fig. 11). At the global level, diversification decreased by 9.7% and 8.7% during these months but less significantly in June (3.7%).

Similar patterns are observed at the regional level. In fact, exports were less diversified in all regions during April and May (in the range of 3.2 to 18.9% across regions and months). In line with increasing export values, Latin American and Caribbean exports were also more diversified throughout the considered period. While the concentration declined slightly again in June in Asia, Northern Africa and—quite significantly—in Latin America and the Caribbean, we observe further export concentration in all other regions.

We also provide information from two alternative measures—the Herfindahl and Gini indices—which reveal similar changes (see Figs. A.8 and A.9). Although the Theil and Gini indices are the two most popular diversification measures, the Herfindahl index is a widely employed trade concentration measure. The latter gives no weight (or very small weight) to zero (close to zero) values; thus, its results divert in some cases from the Theil and Gini indices.

With respect to RQ8, we conclude that the diversity of global agri-food trade decreased since February 2020 but mainly in April and May 2020. Non-staple foods and non-food commodities show the strongest tendency towards concentration. Considering each region separately, all regions, except for Latin America and the Caribbean's exports, show development towards more trade concentration—at least in April and May.

Next, we decompose the Theil index to identify changes in the diversification resulting from the extensive and intensive margins of trade. Changes in the between-group component of the Theil index indicate the diversification of trade flows along the extensive margin of imports (Fig. A.10). At the global level, we observe a reduction in diversification along the extensive margin of trade in April and May by 16.2 and 15.6%, respectively. Therefore, imports occur in fewer trade links relative to the pre-pandemic period. These figures are in line with the changes in the number of active import links in Fig. 6. Similarly, we observe a decrease in import diversification in all regions, noticeably in sub-Saharan countries (more than 40% increase in the between-group Theil index in April and May).

Moreover, Fig. A.11 shows changes in the within-group component of the Theil index—the diversification along the intensive margin of trade given the distribution of import shares in value terms across existing trade links. Diversification along the intensive margin of trade declines at the global level, but the results at the regional level are mixed. Overall, the changes in the diversification along the intensive margin are minor compared with the changes in the diversification along the extensive margin of imports. A comparison of the results of the overall Theil index (Fig. 9) and its components (Figs. A.10 and A.11) suggests that import trade diversification declines mostly through changes in the diversification along the extensive margin of imports.

Similar to the changes in import diversification, the changes in export diversification, as reported by Fig. 11, are mainly driven by changes in the diversification along the extensive margin of trade (Fig. A.12). In this respect, the Latin America and Caribbean region again stands out with strongly increasing diversification along the extensive margin of trade. The within-group Theil index of exports shows that all regions except for Latin America and the Caribbean increased their diversification along the intensive margin in April and May (Fig. A.13).

Concluding on RQ9, on both the import and the export side, changes in the extensive margin of trade towards more concentration dominate the changes in the intensive margin of trade.

4.6 Product and market diversification

Lastly, we use the modified Herfindahl index to show the results of import diversification in terms of trading partner and product differentiation. At the global level, market diversification—the range of countries from which imports are sourced—decreased throughout April, May, and June by 4.1, 11.9, and 18.3%, respectively (Fig. A.14). Therefore, on average, countries imported from fewer trading partners than during the pre-pandemic period. At the regional level, the impact on market diversification is mixed.

Considering the diversification across product groups (Fig. A.15), at the global level, import diversification increased significantly in February (40.8%), mostly driven by changes in the Asian region (33.3%),[14] followed by no significant changes in March. Subsequently, product diversification decreased from April to June. Interestingly, in May and June, the changes in the Herfindahl index of product diversification at the global level is greater than those at the regional levels, suggesting a greater increase in the concentration of imports across products between the different regions relative to the changes in concentration within each region.

A comparison of Figs. A.14 and A.15 reveals that the overall decline in import diversification was mainly driven by a decline in the range of products imported, whereas changes in the number of trade partners played a smaller role. In some regions in which the trade of countries concentrated through market interruptions in March and April, the diversification across products increased, thus mitigating the overall reduction in the diversity of the trade values across trade links. Considering these changes along with RQ10, we state that reductions in trade diversification mainly occurred through a decline in the range of products traded.

5. Summary and conclusions

The pandemic and related containment measures have raised questions over the resilience of the global food system and its ability to ensure importers' access to sufficient import quantity and variety and whether exporters can realize their export earnings. To answer these questions, we provide a short-term analysis of the changes in agricultural and food trade in light of the COVID-19 pandemic and related containment measures. We use monthly data from the first half of 2020 to compare trade indicators, such as trade values, trade links, and various diversification indices, with their pre-pandemic averages. We explicitly consider changes in the intensive and extensive margins of trade and the differences across regions and product groups. At the country level, different pandemic-related factors, including direct health impacts (morbidity and mortality rates), induced policy restrictions (policy stringency and mobility changes), and macroeconomic impacts (industrial output), appear to be related to changes in the trade value and diversification of agri-food trade.

Our results indicate that the changes of agri-food trade values and the extensive margin of trade remained limited to short-term disruptions primarily in April and May 2020. We find that morbidity and mortality rates are not significantly related to import values and trade diversification. However, policy responses implemented to combat the pandemic and the induced macroeconomic changes show parallels with the changes in trade value and diversification measures. Overall, in this regard, non-food commodities experienced relatively more changes than foods, whereby some staple foods were most resilient.

The extensive margin of trade decreased significantly at both the global and regional levels; however, trade intensity increased in some regions. The sharp reduction in the extensive margin of trade dominated the increase in the intensive margin, if any, during the period of heightened policy restrictions, thus leading to a decline in overall trade values in April and May. In June, increasing trade intensity compensated for the reduction in the extensive margin of trade and led to a rebound in trade values. Latin American and Caribbean exports were an exception as trade values and trade links increased during all months. Major exporters in this region increased their export values mostly in the extensive margin of trade, thus alleviating further global reductions in imports during the peak of the first wave of the pandemic.

Considering the changes in exports and imports, net trade position indicators reveal that most regions deepened their net import positions. Northern America and Europe changed their positions from net exporting to net importing regions of food and agricultural products in respective months. Mixed effects were found for changes in inter- and intra-regional trade across regions. For example, the intra-regional trade of sub-Saharan Africa, particularly in the extensive margin, was more prone to reductions than its inter-regional trade. However, the opposite held true for Europe and Northern America.

The diversity of global agri-food trade decreased primarily in April and May 2020. Overall, the deterioration in export diversification was greater than that for imports. More pronounced policy restrictions, reduced workplace and retail mobility, and lower industrial output during COVID-19 are associated with a higher concentration of trade value across a lower number of products and countries.

Changes in the extensive margin were found to play a stronger role than changes in the intensive margin of trade in reducing overall trade diversification. Non-staple foods and non-food items showed stronger concentration tendencies than basic foods. In addition, our results indicate that reductions in the number of products traded were more pronounced than those in the number of trade partners.

The simultaneity of the implementation of strict virus containment measures and the sharp changes in international trade suggest a clear association between COVID-19-related effects and short-term trade disruptions. However, results should be interpreted cautiously as other factors besides the pandemic might have influenced the observed trade patterns during the study period. In addition, while the analysis considers the extensive and intensive margins of trade and provides insights into changes in aggregated agri-food trade quantities based on overall food prices and values, we do not decompose price and quantity components of trade values for each country and at commodity level because of data limitations. Given the observed variations in prices across commodities and countries, the results in this respect should be taken with caution. Lastly, the use of more advanced quantitative methods in future research could provide further insights with respect to quantifying the role that various factors (including macroeconomic variables such as exchange rate fluctuations) play in determining trade impacts.

Data availability

The trade data were obtained from Trade Data Monitor (TDM). The links to all other data sources used in this article are provided in the reference list. The R script used for the analysis is provided as online appendix.

Supplementary material

Supplementary data are available at *Q Open* online.

End Notes

1 Arita et al. (2022) are the first who econometrically examine the factors affecting agricultural trade values and the extensive margin of trade of different products and regions.
2 See Melitz (2003) and subsequent literature on firm heterogeneity showing the negative impact of productivity reductions on trade. Lower productivity increases the cost of production and trade, thereby leading to less profitable firms, which can discourage them from operating in foreign markets.
3 Data limitations mean that we do not consider heterogeneous price impacts across countries and commodities in our study.
4 All agricultural products are HS codes considered under the USDA's BICO definition of Agricultural and Agricultural-related goods, and non-agricultural products cover all other HS codes. They also find that reductions are mainly driven by reductions in the extensive margin of trade (8–10%).
5 The authors associate the recovery with the less stringent restrictions in subsequent months and the learning effects from the preceding quarter that resulted in supply chain adjustments.
6 These differences can be explained by the necessity of food and, accordingly, lower income-elasticity of food products (WTO 2020).
7 An overview of global changes in agri-food trade through December 2020 is provided in Fig. 3.
8 Taking the natural logarithm of both sides ($Ln(Q) = Ln(N) + Ln(q)$) leads to $\frac{dQ}{Q} = \frac{dN}{N} + \frac{dq}{q}$ after total differentiation. Based on this formula, we infer the change in the intensive margin of trade.
9 The export diversifications measures can be simply obtained by changing the notation m to exporter x and vice versa.
10 One reason behind these figures is a change in the trade data reporting of China, which combined data for January and February in 2020 to account for volatility during the Chinese New Year period (Leng 2020). As China is a major exporter and importer of agri-food products, this change in reporting affects not only Asian trade values but might also be reflected in global patterns in January and February 2020 compared with previous years.
11 The deviation of global exports from imports is caused by several reasons. First, we consider the imports and exports reported by ninety-six countries, whereby relatively more countries with higher imports than countries with higher exports are missing. Furthermore, the time lag of the reporting of imports and exports can lead to differences in trade statistics, and imports are often more accurately reported at customs. Another important source of discrepancies is the fact that export values are reported on the basis of Free on Board (FOB) prices, whereas import values are based on Cost, Insurance, and Freight (CIF). Therefore, import values are generally expected to be higher than export values.
12 Although many countries in sub-Saharan Africa are, in fact, net food importers, the sample includes mainly net exporters and also considers trade of a broader range of non-food agricultural commodities. Moreover, a large portion of intra-African trade is not formally reported which might bias results (Malabo Montpellier Panel 2020).
13 Note that the patterns of change of the diversification measures remain the same regardless of whether these measures are applied to trade values or trade volumes.
14 The significant increase in import diversification in Asia might reflect the change in trade data reporting in China in January and February 2020, as previously mentioned.

Acknowledgments

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Appendix

Table A.1. Correspondence between commodity groups and HS2/4/6-digit levels

Commodity groups	HS 2-digits 01-24/HS 4/6-digits
Live animals	01
Meat	02
Fish	03
Dairy products	04
Others	05, 13, 14, 23, 290543, 290544, 3301, 3501–3505, 380910, 382360, 4101–4103, 4301, 5001–5003, 5101–5103, 5201–5203, 5301, 5302
Live plants and cut flowers	06
Vegetables	07
Fruits and nuts	08
Coffee, tea, and spices	09
Cereals	10
Flours, starches, and malts	11
Oilseeds	12
Fats and oils	15
Food preparations	16, 19, 20, 21
Sugar and confectionery	17
Cocoa and chocolate	18
Beverages	22
Tobacco	24
Cotton	5201–5203

Source: WTO (1995), AoA Annex 1 plus fishery products.

Table A.2. Correspondence between regions and countries

Regions	Countries
Asia	Armenia, Bahrain, Brunei Darussalam, China, Cyprus, India, Indonesia, Israel, Japan, Jordan, Kazakhstan, Malaysia, Myanmar, Pakistan, Philippines, Qatar, Republic of Korea, Saudi Arabia, Singapore, Sri Lanka, Thailand, Turkey
Europe	Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo*, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom
Latin America and the Caribbean	Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay
Northern Africa	Egypt, Morocco
Northern America	Canada, United States
Oceania	Australia, New Zealand
Sub-Saharan Africa	Botswana, Egypt, Ethiopia, Ivory Coast, Kenya, Madagascar, Mauritius, Mozambique, Namibia, Senegal, South Africa, Zambia

Note: Countries for which monthly agri-food trade data (from TDM) were available at the time of extraction. The regional aggregation follows the M49 standard of the United Nations Statistics Division (UNSD); *inclusion of Kosovo follows from our data availability.

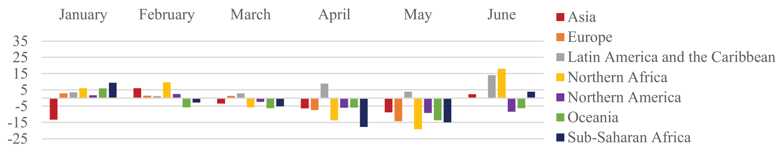

Figure A.1. Export value changes at the regional level (per cent).
Source: Own calculations based on data from TDM.

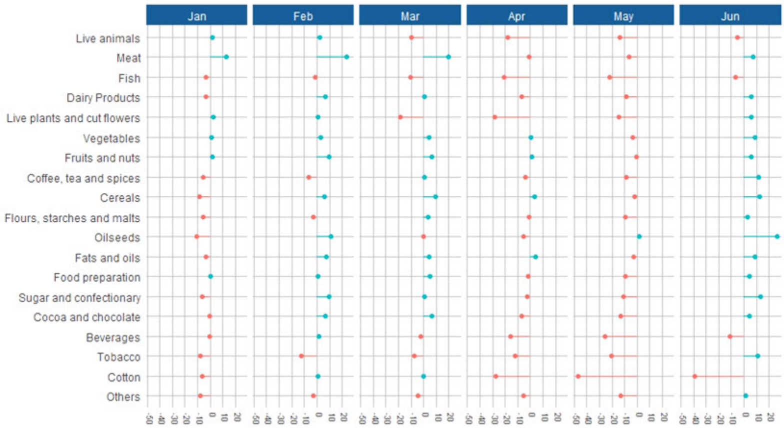

Figure A.2. Global changes in import values at the commodity level (per cent).
Source: Own calculations based on data from TDM.
Note: Changes are calculated as percentage changes in the import values for each commodity group (aggregated as shown in Table A.1) in a specific month in 2020 compared with the average values in the same month in 2018 and 2019.

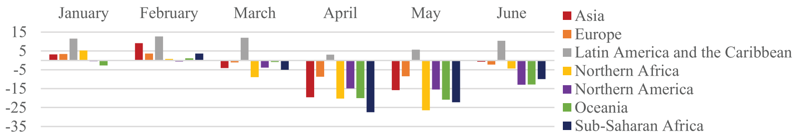

Figure A.3. Changes in the number of active export links at the regional level (per cent).
Source: Own calculations based on data from TDM.

Figure A.4. Net trade positions at the regional level.
Source: Own calculations based on data from TDM.
Note: The net trade position (exports minus imports over exports plus imports) ranges between minus one and one.

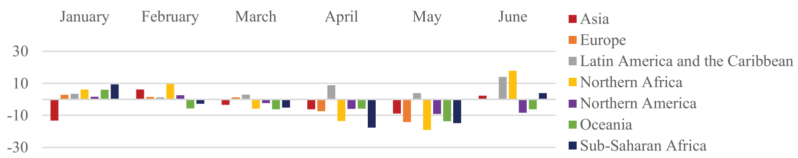

Figure A.5. Import value changes in intra-regional trade (per cent).
Source: Own calculations based on data from TDM.

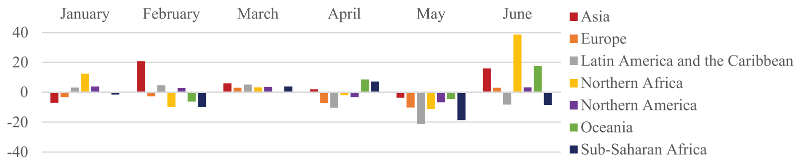

Figure A.6. Import value changes in inter-regional trade (per cent).
Source: Own calculations based on data from TDM.

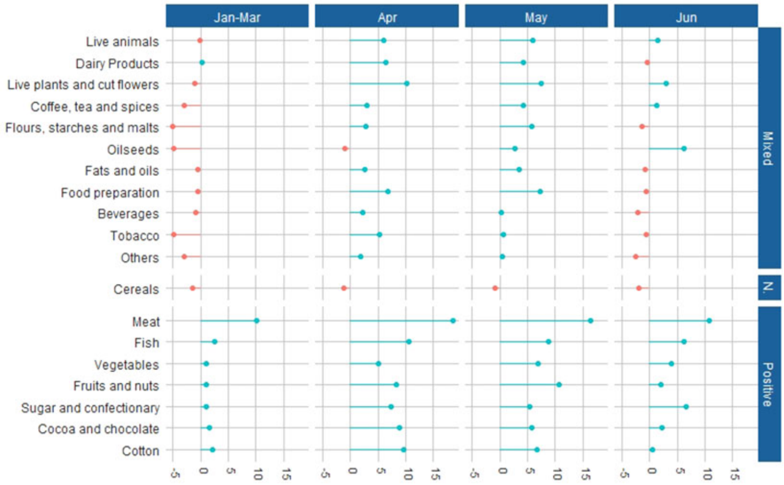

Figure A.7. Global changes in the Theil index of imports at the commodity level (per cent).
Source: Own calculations based on data from TDM.
Note: Figure A.4 shows the changes in import diversification at the commodity level based on the Theil index.

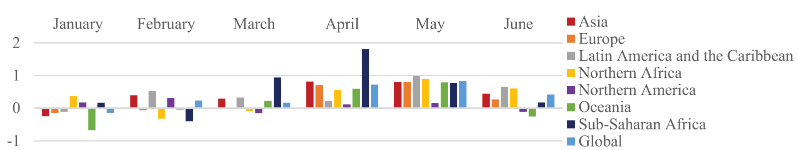

Figure A.8. Changes in the Gini index of imports at the global and regional levels (per cent).
Source: Own calculations based on data from TDM.

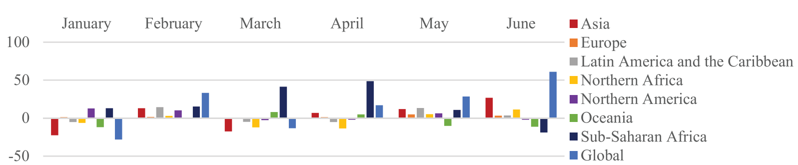

Figure A.9. Changes in the Herfindahl index of imports at the global and regional levels (per cent).
Source: Own calculations based on data from TDM.

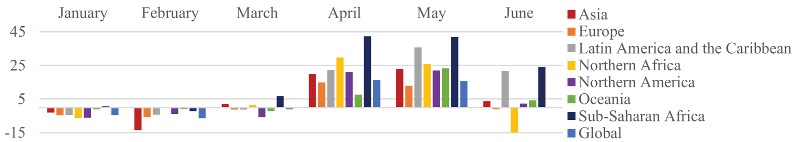

Figure A.10. Changes in the between-group Theil index of imports at the global and regional levels (per cent).
Source: Own calculations based on data from TDM.

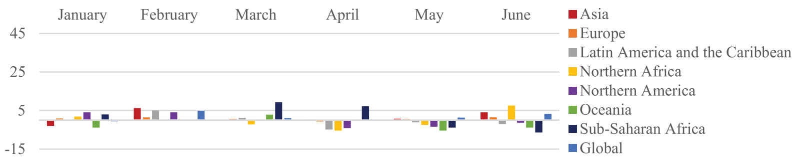

Figure A.11. Changes in the within-group Theil index of imports at the global and regional levels (per cent)
Source: Own calculations based on data from TDM.

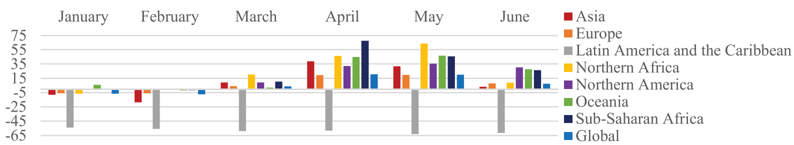

Figure A.12. Changes in the between-group Theil index of exports at the global and regional levels (per cent).
Source: Own calculations based on data from TDM.

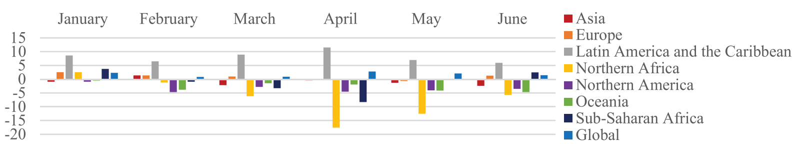

Figure A.13. Changes in the within-group Theil index of exports at the global and regional levels (per cent).
Source: Own calculations based on data from TDM.

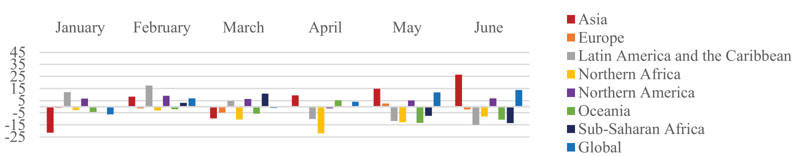

Figure A.14. Changes in market diversification according to the Herfindahl index of imports at the regional level (per cent).
Source: Own calculations based on data from TDM.

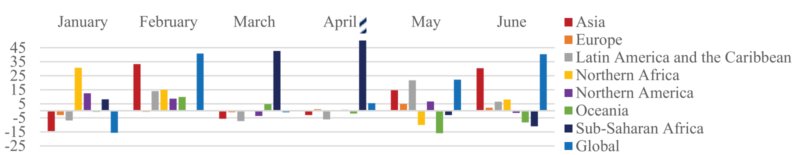

Figure A.15. Changes in product diversification according to the Herfindahl index of imports at the regional level (per cent).
Source: Own calculations based on data from TDM.
Note: In April, the change in the Herfindahl's product diversification index in sub-Saharan Africa is 123.38%.