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Grain export restrictions during COVID-19 risk food insecurity in many low and middle income countries

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Global food security is threatened by the effects of COVID-19 on international agricultural supply chains and locusts destroying crops and livelihoods in the Horn of Africa and South Asia. We quantify the possible impacts on global supplies and prices of wheat, rice and maize. We show that local production declines have moderate impacts on global prices and supply – but trade restrictions and precautionary purchases by a few key actors could create global food price spikes and severe local food shortages.

Some major agricultural producing nations implemented export restrictions in the first half of 2020[1], following market uncertainties triggered by the COVID-19 pandemic[2]. Several events compound COVID-19's disruption to supply chains, including locust infestations in the Horn of Africa and parts of the Middle East and South Asia[3], shortages of farm labour[4,5], a second wave of COVID-19 outbreaks, and dry weather in Europe and South America[6,7]. COVID-19-related lockdowns can impact agriculture directly (mainly through restrictions to farm labour, which is one factor that can reduce yields), meaning regions with high employment in agriculture may experience the largest losses in crop production. For example, the Ebola outbreak in West Africa in 2014 reduced labour availability for farming and led to a 20% decline in rice production[8] during the outbreak, with large economic impacts in following year[9].

We quantified the impact of these various threats to the world supplies and prices of wheat, maize, and rice. These crops form the backbone of global trade in staple crops, with high importance for food security; they comprise 43% of calories and 37% of protein directly consumed by the human population[10]. To determine the supply chain impacts of the COVID-19 pandemic and other threats to these key crops, we combined an analysis of impaired supply with a global agricultural commodity prices model[11] including trade policies and storage. To quantify the impacts of crop failures, we developed scenarios that included a 1-in-5-year production decline due to drought and lock-down effects in three major exporting countries and a 1-in-20-year decline in production in the countries most threatened by the locust infestations as of May 2020. We compared these scenarios to a baseline scenario based on the OECD-FAO supply and demand forecasts for 2020/21, which do not factor in these production shortfalls.

Global stock-to-use ratios of rice, wheat and maize are at historically high levels (Supplementary Figure 1). This situation is in sharp contrast to the recent food crises of 2007/08[12] and 2010/11, which were preceded by low grain stocks. This means that the world currently has significant buffers to production shortfalls. Yet, production failures can cause local food security problems in certain countries that do not have adequate stores (Fig. 1). For instance, a 1-in-20-year shortfall means a loss of about 15% of the average maize harvest in Kenya, or around 7% of the average maize harvest in Pakistan. Pakistan would be able to buffer these supply losses by tapping into domestic reserves but Kenya would face impaired availability without additional imports or food assistance (Supplementary Tables 1-3). Fortunately, these production declines would only lead to a moderate impact on global food web stability. The world market price of wheat would increase by ~10%, maize would increase by ~7%, and rice by <5% (Fig. 1). Thus, current high stock levels make a global staple crop shortage unlikely within the current agricultural year, even if production shortfalls of the same size as those preceding the 2007/08 and 2010/11 crises were to occur. At the same time, local food insecurity may arise in some countries with little integration into global markets or low food reserves – food prices in a country are driven by multiple factors including domestic harvest, national buffering infrastructure (e.g. food storage) and exchange possibilities (e.g. access to agricultural commodity markets)[13].

Widespread lockdowns to deal with the COVID-19 pandemic prompted concerns about food supply chains[14]. A surge in demand as consumers purchased food for quarantine led to a temporary emptying of grocery store shelves around the world and created concerns about the availability of food[5]. To better understand these concerns, we explored the impact of export restriction and temporary increases in world demand through a set of stylized scenarios in three major exporting countries for each of the three main staple crops. Together, these nations account for over 13%, 16%, and 33% of global production and 34%, 59%, and 55% of the global export of wheat, maize, and rice, respectively. The World Trade Organization prohibits export restrictions except to prevent or relieve critical domestic shortages of foodstuffs, yet major exporters have frequently restricted exports to insulate their domestic markets from world market price volatility and as a precautionary measure to protect domestic food supply when harvest failures loom[15]. Stock levels are currently much higher than before recent food crises but export restrictions and aggressive stock up attempts still have the potential to send world grain prices soaring[16]. For instance, the International Grains Council's wheat, rice and maize commodity price index increased 12%, 15% and 26%, respectively, from January to October 2020 (Supplementary Figure 2).

In the scenario with export restrictions, we assumed that three major grain-exporting countries imposed complete export bans, and thus reduced the amount of grain in the international trade system by their respective shares of world exports for the entire agricultural year (see Supplementary Information (SI)). We estimate that the wheat price would rise 70% under this scenario, which is a larger price hike than during 2007/08 (Fig. 1). For maize and rice, prices would rise by 40% and 60%, respectively. Being suddenly stripped of more than a third of their annual grain supply, many low-income and lower-middle-income countries in Africa and Asia would not be able to buffer this decline in grain supply with their domestic reserves (Fig. 1, Supplementary Tables 4-8) and would have to find alternative suppliers. This task would be difficult in times of tight world markets, because these nations could be outbid by wealthier importers. Furthermore, many of the low-income countries that are especially vulnerable to increased trade restrictions are also likely to experience domestic agricultural production challenges during the COVID-19 pandemic, because they have a large agricultural labour force. If there were a moderate 1-in-5-year increase in demand (e.g. driven by stock-up-attempts of wealthy importers in addition to export restrictions and production shortfalls), the prices of wheat, maize and rice would increase by about 90, 100% and 50%, respectively, exacerbating the situation (Fig. 1).

Two approaches are needed to maintain food security during the COVID-19 pandemic: a proactive strategy to maintain food access among poor households and a concerted effort to keep major exporters from enacting trade restrictions. International institutions like the World Food Program are focused on raising awareness and bringing food to food-insecure people in over 80 countries worldwide. The estimated number of people in need of emergency assistance is up 25% from the pre-COVID-19 level of 113 million people earlier in 2020. Due to the extreme events of 2020, many more people face hunger now than in the last three years (e.g., 84 million (2017), 80 million (2018) and 86 million people (2019)[17]). Thus, a major humanitarian focus should be to provide cash to maintain food access for those people whose incomes have been lost due to the COVID-19 recession.

In contrast, prohibiting trade restrictions is not as straightforward. For example, Ukraine and Argentina are two middle-income exporting countries and are crucial for the global food system – in 2018/19 Ukraine was the 5th largest wheat exporter and 4th largest maize exporter, while Argentina was the 6th largest wheat exporter and 3rd largest maize exporter. Besides the COVID-19 crisis, these countries are experiencing political, economic and security pressures, which may threaten their ability to export. Ukraine depends on foreign credit and is struggling with an ongoing low-intensity war in the Eastern part of the country; Argentina has experienced severe increases in poverty, currency devaluation, high inflation rates and now bankruptcy. These countries have small reserves relative to their domestic consumption – our calculations suggest that they would not be able to buffer a moderate 1-in-5-year production decline (see SI for details).

The impact of complete export restrictions in Ukraine and Argentina would put the stability of the global food system at risk and harm local producers by reducing their global sales. Domestic food security and global food system stability could be maintained through moderate consumer support policy measures. For example, a temporary reduction of import tariffs or moderate restrictions in export volumes that change the import-export balance of these countries by only a few percent should be sufficient to maintain domestic food security and minimize risk to international commodity markets and trade.

Many poor and vulnerable households have already suffered hardship during the COVID-19 pandemic - timely and coordinated responses can minimize threats to food security around the world. Cash flow is critically needed for poor households to enable food purchasing following the COVID-19-induced recession. Global food supply chains and trade should be allowed to operate freely in order to ensure affordable staple grains for the world's poor and avert a humanitarian crisis. Thus, the international community, including international institutions, agri-businesses, charitable organizations and nations must cooperate to minimize food insecurity during a time period of unprecedented local and global threats.

Methods

We used a year-to-year supply-demand model including consumer and producer stocks to estimate global export prices of grains[11]. At the market clearing price P, supply $Q_s \propto P^{e_s}$ equals demand $Q_d \propto P^{e_d}$ where e_s and e_d denote the price elasticities of supply and demand, respectively. Stocks on the supply (producer) and demand (consumer) sides of the market are updated according to

$$I_p(t) = I_p(t-1) - Q_x(t) + H(t), \tag{1}$$
$$I_c(t) = I_c(t-1) + Q_x(t) - Q_{out}(t), \tag{2}$$

where I_p and I_c denote producer and consumer storages, respectively, Q_x is the quantity sold/bought, H is the production (harvest), and Q_{out} is the consumption (see SI for details). The model is driven exogenously by annual time series of global production and consumption and calibrated individually for wheat, rice and maize using data from the USDA PSD database[18] for the period 1975-2019. The baseline price for 2020/2021 is calculated from global projections provided in the OECD-FAO Agricultural Outlook 2019-2028 report[19]. The model does not contain any possible cross-market connections between different commodities.

We modelled three different types of impacts: i) regional production failures are modelled by reducing the projected world production for 2020/21 but keeping consumption fixed to the projected value, ii) export restrictions are modelled by reducing world market supply and demand by the domestic consumption of the countries issuing the export restrictions for one timestep and transferring the corresponding amount of grain to the consumer site storage, and iii) stock-up attempts are modelled by increasing the consumer target storage level. Price changes are given with respect to the baseline price. Details on how the scenarios were derived based on USDA data from the last 20 years are provided in the SI.

In addition to the price modelling, we studied the supply balances at the country level. For that, we considered the annual balance of wheat, rice and maize commodities (separately) in kilocalories for each country,

$$S = H + I - E, \tag{3}$$

where S, H, I, and E denote domestic supply, national production (harvest), imports and exports, respectively. We use country-to-country trade and country-level production data from the FAOSTAT database[20] and reserves data from the USDA[18] averaging over the years 2015-2017 (2017 is the last year for which bilateral trade data are available). We estimated the country level impact of export restrictions by setting the export of the countries issuing the restrictions to zero. We also modelled production losses in major producing countries and locus threatened countries. For each scenario, the combined impact of these disturbances was estimated by computing the domestic "impaired" supply as the absolute value of the difference between the supply in the baseline scenario (cf. Eq. 3) and in the perturbed scenario. Change in impaired supply was then compared to the size of the domestic reserve in order to determine which of the countries cannot buffer the impaired supply by their reserves.

Data availability

The data that supports the findings of this study is publicly available from the USDA PSD database [https://apps.fas.usda.gov/psdonline/], the FAO FAOSTAT database [http://www.fao.org/faostat/], the World Bank commodity markets database [https://www.worldbank.org/en/research/commodity-markets] and the US Bureau of Labor Statistics [https://www.bls.gov]. The data generated during the current study is included in this published article (and its supplementary information files).

Code availability

The global supply-demand model (TWIST) used to compute the grain prices is open source and available at https://gitlab.pik-potsdam.de/twist/twist-global-model/-/tree/COVID19_paper

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Author contributions

T.F., C.O., J.S. and M.J.P. conceived the concept and developed the scenarios. T.F. performed the price simulations and M.J.P. made the country level trade balance calculations. J.J. Produced the figures. T.F., J.S., C.O. and M.J.P. co-wrote the paper. J.J., M.Ko. and M.Ku. contributed to editing the manuscript. T.F., C.O., J.S., M.J.P. J.J., M.Ko. and M.Ku. contributed to data interpretation. T.F. wrote the SI. B.W. provided policy advice.

Competing Interests

The authors declare no competing interests.

Additional information

Supplementary Information is available for this paper.

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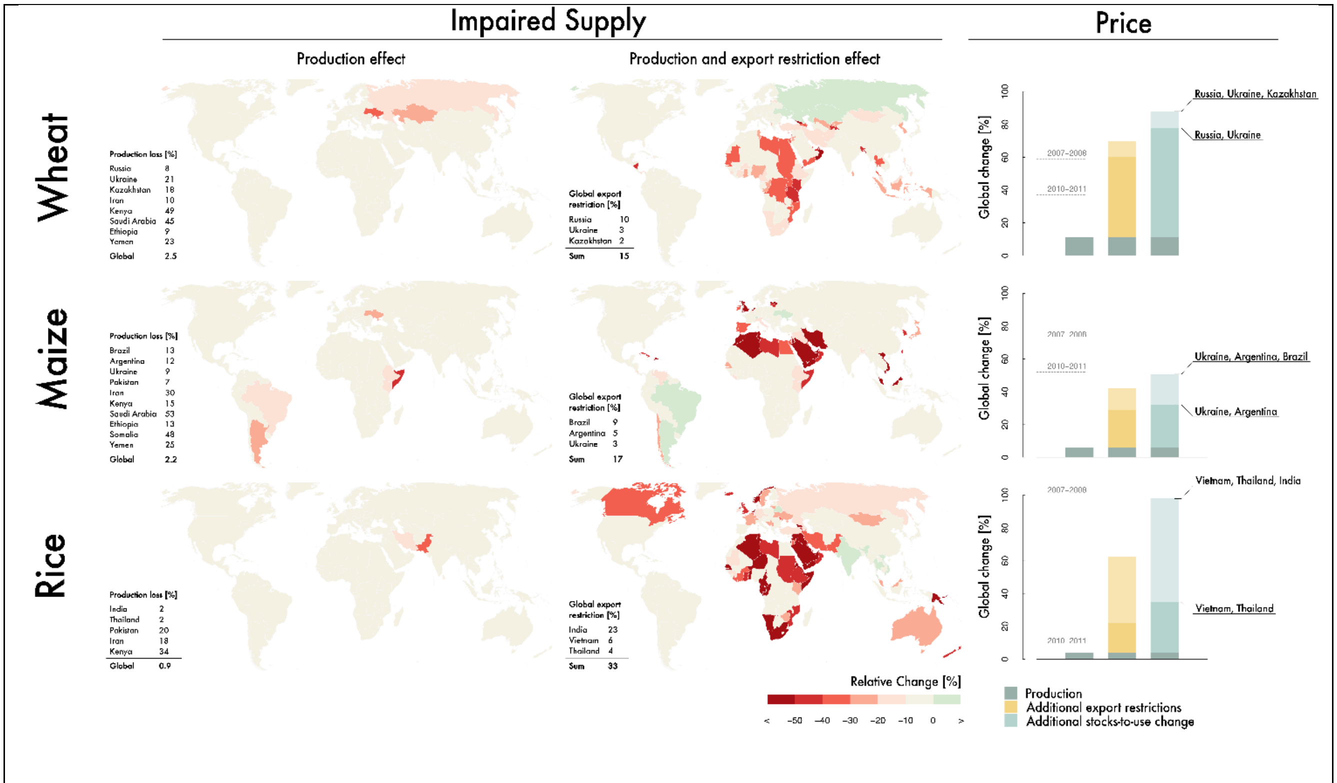

Fig. 1| Food security impacts of production failures and unilateral trade policies. Domestic supply changes due to potential production declines (left) and export restrictions (right). Supply changes do not consider changes in trade or use of reserves and therefore represent the “impaired supply” that must be recovered; inset tables detail production and export assumptions. Estimated changes in world market prices arising from production declines (grey bars), additional export restrictions (yellow bars), and additional consumer stock-up attempts (green bars). Dashed lines indicate price levels during the 2007/08 and 2010/11 food price crises. See SI for details on data and methods.