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Strengthening the resilience of agricultural supply chains

The case of fresh fruits and vegetables

Background paper prepared for the “Guidelines to increase the resilience of agricultural supply chains: Getting on the Right Track to Stabilize Production and Markets” project

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Strengthening the resilience of agricultural supply chains

The case of fresh fruits and vegetables

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Abstract

Fresh fruits and vegetables constitute important commodities in world agricultural production, trade and consumption. Their typically high nutritional value makes fresh fruits and vegetables a critical component in ensuring global food security and nutrition. Since a large share of fruits and vegetables are produced in low-income countries, concerns regarding equitable smallholder incomes and foreign exchange generation also play a special role. Over the past decade, global trade in fresh fruits and vegetables more than doubled in response to rising demand, placing this commodity group among the most valuable food commodities in terms of export value. As such, fresh fruits and vegetables constitute telling examples of high value and sometimes delicate export crops with challenging transport needs, with supply chain disruptions negatively impacting on producers, exporters and end users. The need to keep supply chains functioning and to facilitate the availability and affordability of fresh fruits and vegetables, is of eminent importance in times of crises, whether these are linked to economic difficulties, disease outbreaks, conflict, natural disasters or other factors. This paper lays out some of the salient features of global trade in fresh fruits and vegetables and the special characteristics pertaining to their supply chain needs. It presents an investigation of market developments observed in 2020/2021 and investigates the potential implications of shocks to supply chains, in order to highlight bottlenecks to be addressed to strengthen the resilience and preparedness of supply chains in times of crises.

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FAO gratefully acknowledges funding for this research provided by the Government of Japan under the project “Guidelines to increase the resilience of agricultural supply chains: Getting on the Right Track to Stabilize Production and Markets.” The project, which was in operation from April 2021 to June 2022, was conceived in the wake of the COVID-19 pandemic, which, through the imposed containment measures and a myriad of direct and indirect transmission channels, has harmed economic activity, impacted food systems, disrupted agricultural value chains and put households’ food security at risk by undermining their livelihoods and capacity to access food. In particular, low- and middle-income countries could be severely affected, as large shares of their populations depend on agriculture for their livelihoods. As the COVID-19 pandemic unfolds, considerable attention has focused on the resilience of food supply chains in times of crises. Agricultural and input supply chains have had to adjust rapidly to demand-side shocks, including panic buying and changes in food purchasing patterns, as well as plan for any supply-side disruptions due to potential labour shortages and disruptions to transportation and supply networks. Drawing on its experience and expertise in agricultural markets, trade and economic analysis of agricultural policies, FAO has undertaken research, including the case study presented in this paper, on the impacts of the COVID-19 crisis, as well as of other natural disasters, on agricultural supply chains and markets. The findings have fed into the preparation of the “Guidelines for increasing the resilience of agricultural supply chains.”

Abbreviations

COVID-19	Coronavirus disease 2019
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GDP	gross domestic product
HHI	Herfindahl-Hirschman Index
ICA	Colombian Agricultural Institute
IMF	International Monetary Fund
NPPO	national plant protection organization
OECD	Organisation for Economic Co-operation and Development
TR4	Banana Fusarium Wilt Tropical Race 4
USD	US dollars
WTO	World Trade Organization

1. Introduction: the significance and characteristics of fresh fruit and vegetables supply chains

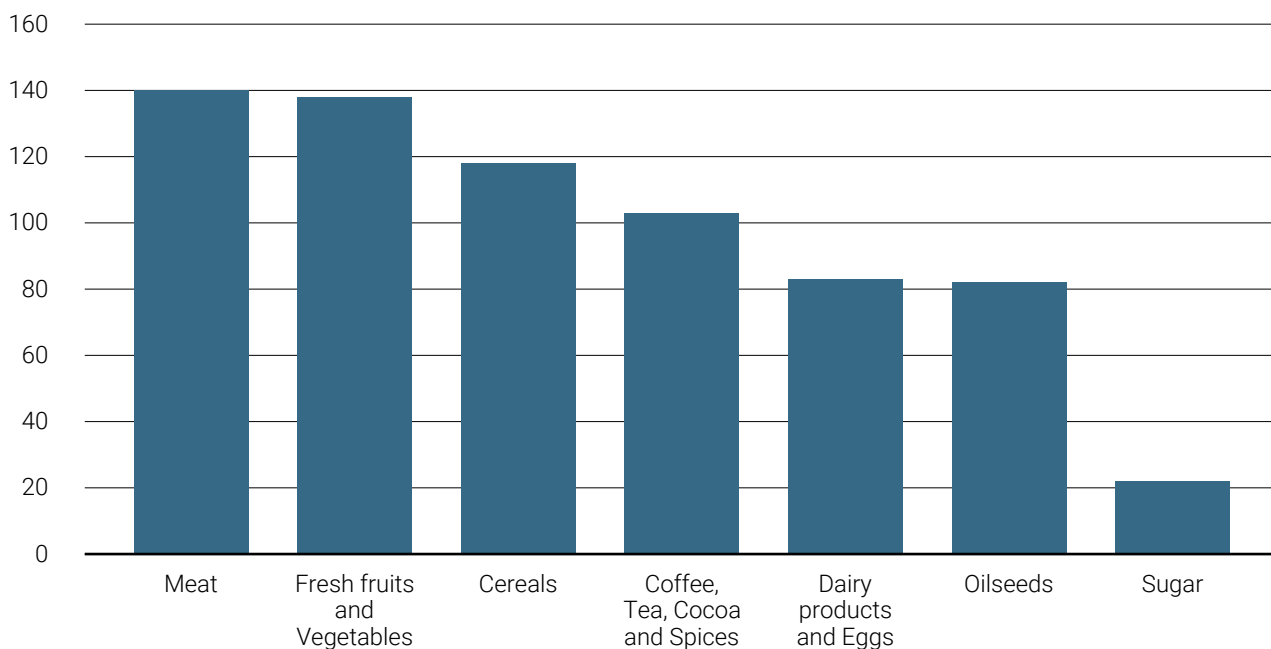
Measured against their production quantities, fresh fruits and vegetables are among the lesser internationally traded food commodities, with combined exports representing, on average, only some seven to eight percent of total global production (FAO, 2021). Due to their typically high perishability, fresh fruits and vegetables, with some notable exceptions, are mostly traded locally or nationally and hence tend to be consumed domestically. Despite its low export-to-production ratio, the fresh fruits and vegetables category ranks among the most valuable agricultural commodity groups, with a global value of exports amounting to approximately USD 140 billion in 2018 (Figure 1). The export unit values of fresh fruits and vegetables average USD 1 000 per tonne, with high value products such as asparagus and berries trading at a multiple of this. In addition, export quantities of many fresh fruits and vegetables, notably of major tropical fruits,¹ have experienced some of the fastest average annual growth rates among internationally traded food commodities in recent decades, and significantly outpaced their production growth, thanks to advances in transportation and storage technologies, trade agreements, rising incomes and shifting consumer preferences in favour of these food items.

In constant value terms, a measure used to analyze the evolution of trade volumes over time, total global trade in fresh fruits and vegetables has more than doubled between 2000 and 2018 (+115 percent, see Figure 2).² On average, fruits account for approximately 60 percent of total trade and vegetables for some 40 percent. The main traded fresh fruits and vegetables are bananas, tomatoes, apples, oranges and onions, in decreasing order. Latin America and the Caribbean and Asia have established themselves as the two most important exporting regions of fresh fruits and vegetables globally, due to favourable land and climatic conditions that enable large-scale and year-round production of many varieties, as well as the development of trade-supporting infrastructure. Mexico, Chile, Türkiye, China and Thailand are among the most notable global fresh fruit and vegetable exporters from these two regions in terms of trade value, alongside Spain and Italy in the European Union. On the import side, the European Union, the United States of America, China, Canada, Japan and the Russian Federation are the key recipients of fresh fruits and vegetables.

¹ These include the commodity cluster mango, mangosteen and guava; pineapple; avocado; and papaya.

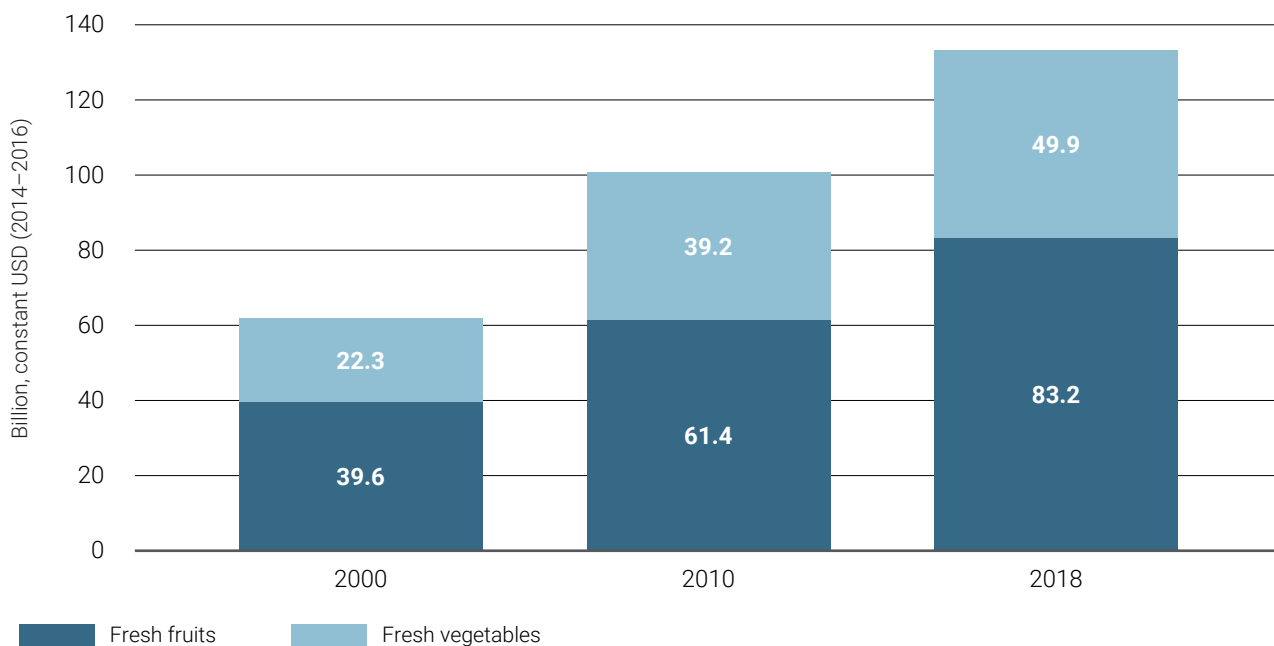
² FAOSTAT data, weighted by 1999–2001 average unit values and aggregated as per the definition of fresh fruits and vegetables of the International Year of Fruits and Vegetables.

Figure 1. World export value of selected agricultural commodities 2018, Billion USD



Source: FAO. 2020. FAOSTAT [online]. Rome. <http://www.fao.org/faostat/en/#home>

Figure 2. Evolution of world fresh fruits and vegetables exports – total aggregate volume increased by 115 percent between 2000 and 2018



Note: Weighted by 1999–2001 average unit values and aggregated as per the definition of fresh fruits and vegetables of the International Year of Fruits and Vegetables.

Source: FAO. 2020. FAOSTAT [online]. Rome. <http://www.fao.org/faostat/en/#home>

Rising demand in developed country markets has been the predominant factor fuelling the expansion in global shipments, particularly in the United States of America and the European Union, the two largest importing blocs, where increasing health consciousness and more widespread awareness of the nutritional benefits of fresh fruits and vegetables is contributing to increasing consumption. Campaigns promoting the health benefits of nutrient-rich fruits and vegetables and the growing availability of ready-to-eat products have further stimulated demand. Indeed, changing consumer preferences are manifest in the year-round availability of fresh fruits and vegetables once regarded as highly seasonal. Significant innovations in distribution technology and logistics in recent decades have lowered transport costs and delivery time, making fresh fruits and vegetables available and affordable year-round in major destinations in the world (Altendorf, 2017). Trade policy has also played an important role in easing commercial flows by means of lowering trade barriers. This was achieved, for instance, by reducing import tariffs as the result of Regional Trade Agreements as well as due to the WTO Agreement on Agriculture (FAO, 2017).

Global demand for many fresh fruits and vegetables is shaped by relatively high responsiveness to changes in prices as well as income. For tropical fruits, for example, available data show a strong relationship between fluctuations in income and demand in the major import destinations, namely the United States of America and the European Union, particularly for pineapples, mangoes and, to some extent, papayas (FAO, 2017). By contrast, import demand for avocados has exhibited much more resilience to changes in income, especially over the past decade, and appears more determined by changes in consumer preference, as demonstrated by the fruit's uninterrupted robust growth in both major import markets, namely the United States of America and the European Union (Altendorf, 2017). Demand for fresh fruits and vegetables in major consuming regions, meanwhile, has been supported by rising incomes, as for example witnessed in India and Brazil, where mango and papaya consumption has been expanding among an increasingly affluent population (Altendorf, 2017).

In producing countries, export earnings from fresh fruits and vegetables can play a significant role in agricultural GDP. Bananas and tropical fruits, for example, are predominantly produced in low-income countries in the tropical belt, where exports can generate important foreign exchange that can then be used to import other goods. Fresh fruits and vegetables, which in some cases feature high returns per hectare, can therefore be promising commodities for low-income countries seeking to diversify exports. Moreover, in many fruit and vegetable industries, smallholders play a key role in the cultivation and processing of fresh produce. To highlight just two examples, some 200 000 rural families are reported to be directly involved in, and benefiting from, banana production in Guatemala, while around 80 percent of avocado production in Mexico is estimated to be carried out by smallholder farmers (Altendorf, 2019a). Fair inclusion of smallholder producers in global value chains, which tend to be dominated by

large national or multinational firms, and equitable wage levels for workers employed in these industries are therefore critical for the most vulnerable to reap the benefits of international trade. Ensuring remunerative prices and fair wages, improving smallholders' productivity and their bargaining power, enhancing resilience to climatic disasters and other shocks, and linking remote producing areas to markets are critical to ensuring inclusive growth and sustainable rural development.

Aside from income opportunities for smallholders and producing countries, trade in fresh fruits and vegetables plays an important role in nutrition. Sustainable value chains for fresh fruits and vegetables can promote healthy diets by facilitating nutrition diversity for producers via income generation, and for consumers via an improved availability and affordability of nutritious foods. In this regard, imports of fruits and vegetables are particularly important to ensuring the nutrition needs of countries that are not producers.³

1.1. Challenges to supply chains in times of crises and the importance of keeping chains functioning

As outlined, income from fruit and vegetable production and trade can account for a substantial share of producing countries' export earnings as well as smallholders' income. In Cambodia, for example, fruits and vegetables are the second most important commodity group after rice in value terms and provide the main additional source of income for most households in the country, while in Ecuador and Guatemala, bananas account for respectively some 42 percent and 17 percent of agricultural export revenue, as measured on the basis of 2018 trade data. The consumption of fresh fruits and vegetables can further contribute vitally to nutritious diets that help to maintain a healthy immune system. The need to keep value chains functioning and to ensure the sufficient availability of, and equitable access to, fresh fruits and vegetables, is therefore of eminent importance in times of crises, whether these are linked to economic difficulties, disease outbreaks, conflict, natural disasters or other factors.⁴

There are various challenges that can pertain to global fruit and vegetable value chains in times of crises. They can be distinguished between challenges to the availability of produce and challenges to consumers' access to fresh fruits and vegetables. As regards availability, fresh fruits and vegetables are particularly vulnerable to supply chain disruptions due to their short harvesting periods and – oftentimes high – perishability. Adverse weather

³ A detailed outline of the role of trade in nutrition is available in FAO (2018).

⁴ More information on value chains during times of crisis can be found in the FAO web resources on COVID-19 (<https://www.fao.org/2019-ncov/en/>) as well as (Torero Cullen, 2020).

events such as droughts, floods and storms are therefore a key threat to supply (see Box 1), especially since they are expected to increase in frequency and intensity due to the impacts of global warming. Since fruits and vegetables often require labour-intensive, timely and well-coordinated harvesting and post-harvest handling, as well as uninterrupted cold chains, any disruption to the availability and productivity of labour, as for example experienced during the COVID-19 pandemic-related lockdowns, can also quickly impede supply. Moreover, disruptions to transport can be another critical obstacle to efficient value chains, as fresh fruits and vegetables rely on smooth transition times and in some cases on airfreight for their export.

In terms of access, since many fruits and vegetables are high value food items, consumption can be greatly sensitive to price and income changes. Especially among low-income consumers, who need to spend a higher proportion of their income on food, demand for fresh fruits and vegetables is observed to be particularly susceptible to income shocks and changes in prices relative to those of other food items, whereby a sudden increase in the relative price or a shock in income can quickly lead to substitution by other food items. Given the importance of fresh fruits and vegetables in income generation and nutrition diversity, there is an elevated need to assure the smooth continuation of supply chains, equitable distribution of value and prevention of price spikes in times of crises.

Box 1. Weather-induced shocks – the example of tropical fruits

Given the highly perishable nature of tropical fruits in production and in distribution, environmental challenges are among the key obstacles to sustaining production and ensuring international markets are supplied. This is a particularly acute challenge since the vast majority of tropical fruits are produced on smallholder farms of less than 5 hectares, where cultivation is highly dependent on rainfall and prone to the adverse effects of increasingly erratic weather events. In recent years, adverse weather conditions have caused considerable disruptions to global production for all of the four major tropical fruits – mangoes, pineapples, avocados and papayas. In 2016/2017, for example, the production of mangoes was affected by drought in some of the major producing countries in Asia, South America and Africa, while pineapple and avocado production underwent damage from flooding in the key producing countries in Central and South America. Drought also hampered the production of papaya in the largest producing regions in South America, as well as the production of avocado in the southern part of Africa. Further examples of recent occurrences of destructive climatic events include low temperatures and floods affecting bananas and pineapples (Costa Rica 2019); tropical storms affecting bananas in

Honduras (2020) and the Dominican Republic (2017–2019); and drought and cold spells in avocado production areas in Mexico (2020–2021). On average, new avocado plantings only bear fruits after four years, making avocado considerably vulnerable. Similarly, pineapple production is prone to adverse weather due to the fact that each plant bears only one fruit per year. More critically, long-lived mango trees bear fruit only after some six years and take between three and six months for fruits to ripen. Conversely, papaya plants can be grown in a plethora of topical soils, are fast growing and more resilient to changing weather conditions than most other tropical fruits. This makes papaya less prone to weather effects. The intensity of the tropical storms in the Caribbean in recent years has been particularly alarming to the tropical fruits industry, as devastating damage to harvests occurred in several small island states, including Cuba, Dominica and the Dominican Republic, where tropical fruits provide important sources of nutrition and income. In the Dominican Republic, for instance, measures to boost the country's exports of tropical fruits have been significantly undermined by poor weather and hurricane damage. By contrast, in the important avocado-producing regions of Central and South America, which have widely installed more weather resilient systems, production has proven better able to withstand disruptive climatic events, highlighting the potential that adaptation measures may provide.

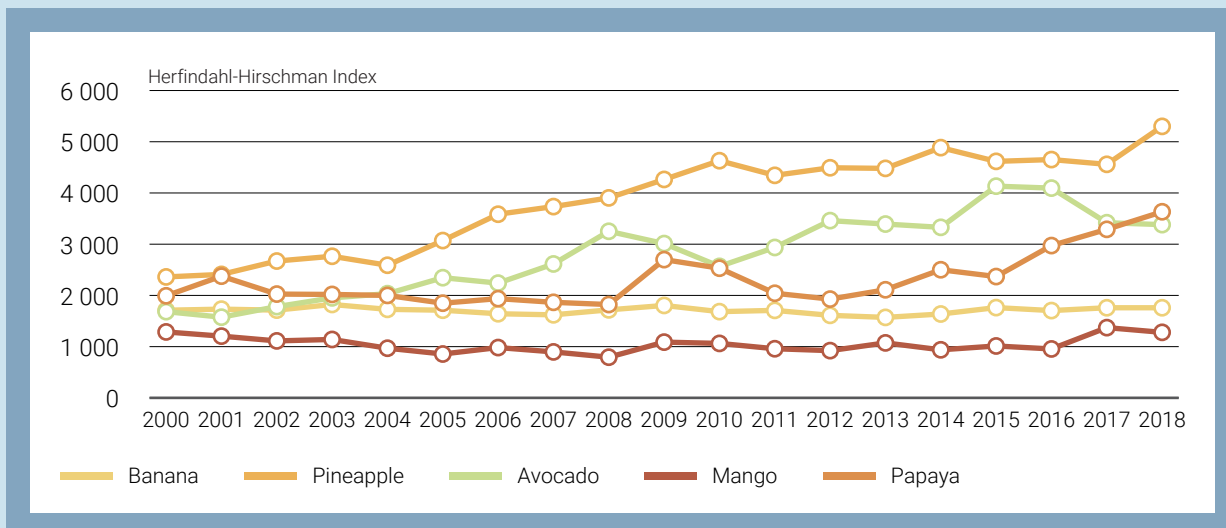
Box 2. Rising market concentration as a vulnerability – the example of global banana and tropical fruit markets

Global markets for bananas and tropical fruits have become substantially more concentrated since 2000, as demonstrated by the Herfindahl-Hirschman Index of exporters (Fig. 3).⁵ Rapid increases in market concentration have particularly affected trade in pineapples, papayas, and avocados, although for avocados some decline has been seen in recent years due to the entry of new exporters.



⁵ The Herfindahl-Hirschman Index (HHI) is the sum of squares of the market shares of all participants in percentage terms. Hence it has a maximum value of 10 000 in the case of one participant with 100 percent market share. The lowest value of the index depends on the number of participants, where for example equal market shares for ten participants would result in a value of 1 000, and for 100 participants in a value of 100.

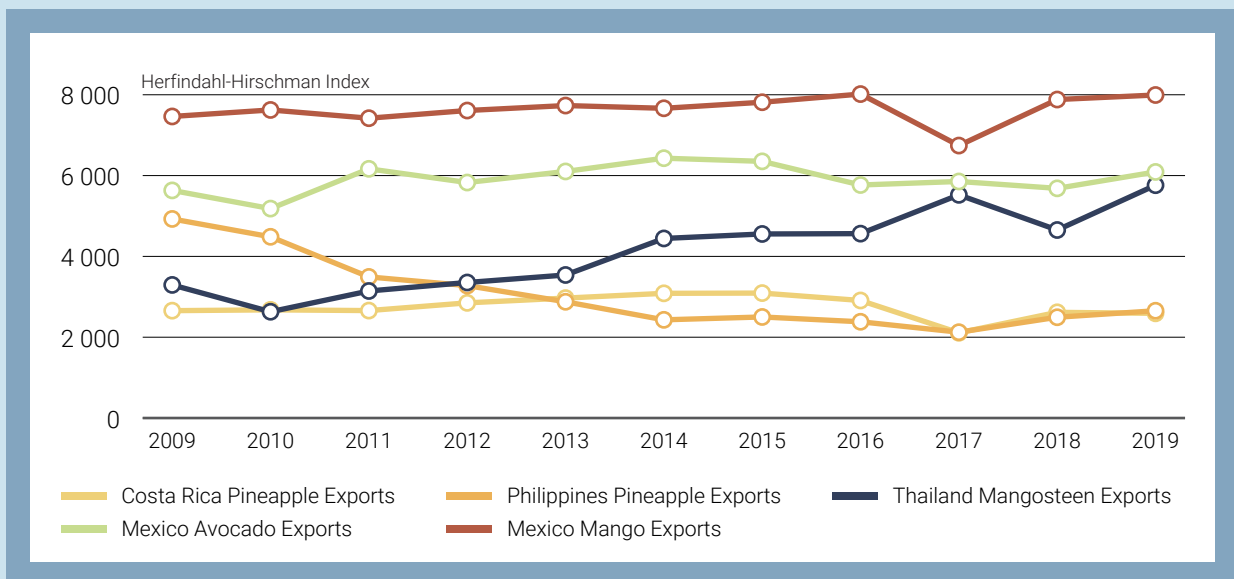
Figure 3. Evolution of market concentration in banana and tropical fruit exports, 2000–2018



Source: Author's calculations.

Similarly, exports from several of the major suppliers of tropical fruits are characterized by high concentration in terms of their destination (Fig. 4). Exports of mango and avocado from Mexico, for example, are highly dependent on imports by the United States of America. Exports of mangosteen from Thailand have increased rapidly in recent years due to strong import demand from China. This has resulted in mangosteen exports from Thailand having become more concentrated in terms of destination. Exports of pineapples from the two largest exporters, Costa Rica and the Philippines, conversely show a comparatively low concentration of destination. High concentration in global trade threatens to render supply chains significantly more susceptible to shocks since links within the chain are fewer and more significant, unless non-market facilitation mechanisms can be developed to manage the consequences of shocks.

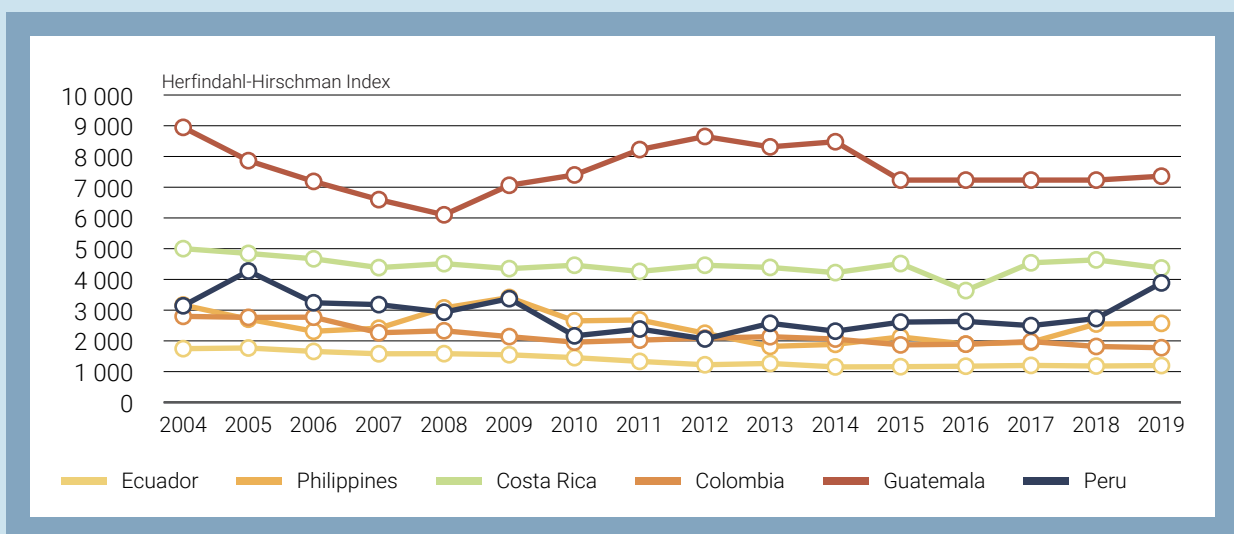
Figure 4. Major exporters of tropical fruits – concentration of exports by destination



Source: Author's calculations.

Exports of bananas from the major suppliers show varying levels of concentration in terms of destination, with a tendency towards high concentration (Fig. 5). Exports from Guatemala show the highest concentration of exports due to the predominant role of the United States of America as an importer of Guatemalan bananas. Interestingly, exports from Ecuador are characterized by the lowest concentration of destination among the major suppliers. Further research on the precise effects of this may shed light onto whether this might be a critical reason for Ecuador's exceptional success in global banana markets up to 2020, or vice versa.

Figure 5. Market concentration – supplies from key banana exporters by destination



Source: Author's calculations.

1.2. Fruit and vegetable markets during the COVID-19 pandemic

Since the onset of the COVID-19 pandemic, a smooth continuation of global supplies of fresh fruits and vegetables has been jeopardized by the impact of the disease itself, the disease mitigation measures that have been implemented, and the economic repercussions that have shaken world economies. These factors have been discernibly affecting the production, transport, distribution, marketing and consumption of these commodities throughout most of 2020 and 2021, with disruptions and contractions widely reported (see Box 3). At the same time, surges in consumer demand for vitamin-rich fruits and vegetables have facilitated fast growth in trade for some commodities in some markets. Preliminary market results on 2020/2021 developments in global trade in bananas and tropical fruits are provided as illustrative examples in the next section.

Box 3. Types of supply chain disruptions reported in 2020

- Lockdowns and social distancing measures limiting labour availability for production and harvesting (e.g. for bananas in the Philippines and mangoes in India)
- Disruptions to international air transport (e.g. for mango exports from Brazil and India)
- Shortages in reefer containers (e.g. for pineapples from Costa Rica)
- Cancellations of import orders (e.g. for papaya and pineapple shipments from Ghana)
- Wholesale and market closures (e.g. for mangoes in India)
- Movement restrictions hindering marketing (e.g. for the procurement of litchi in Punjab, India)
- Border closures (e.g. for the near-shut down of the Mexican-US border; Türkiye's borders with the Islamic Republic of Iran, the Syrian Arab Republic and Iraq).

On the supply side, the adverse effects of not only the disease spread but also of the physical distancing measures have tended to be more immediate and pronounced for the relatively labour-intensive production and trade of fruits and vegetables than for most other food commodities, particularly staple foods. Given their typically high perishability, fresh fruits and vegetables require timely and well-coordinated harvesting and post-harvest handling, as well as uninterrupted cold chains. Some major tropical fruits, such as fresh mangoes, furthermore, partly rely on airfreight for export. In many producing countries, quarantine-related delays at ports and borders, border closures, as well as extreme shortages of refrigerated containers and airfreight belly-capacity, have slowed trade, while market closures have interrupted producers' access to local and national distribution outlets. With input factories and import routes disrupted, reduced availability and higher costs of key inputs for production and

distribution have further jeopardized a smooth continuation of supply. In particular in 2021, the drastic increases in the costs for inputs and global transportation have added substantial difficulties for growers to produce in adequate quantities and qualities, and for exporters to operate smoothly and profitably. Reports of produce remaining unsold and going to waste have been widespread, particularly for more perishable varieties such as papayas and pineapples. Under these circumstances, the profitability of many farms and plantations has been severely affected, with industry sources reporting difficulties arising from cancelled orders, particularly for small- to medium-sized producers.

On the demand side, the rapid decline in global economic activity has resulted in negative impacts on the global incidence of unemployment, poverty, inequality and undernourishment. Reduced consumer incomes have resulted in reports of reduced demand in the fruits and vegetables sector globally, given the high income elasticities of demand for the majority of these high-value commodities (Nzaku, Houston and Fonsah, 2012). This has particularly impeded consumers' ability to pursue healthy nutrition in low-income and least developed countries, where food has a disproportionately higher share in household expenditures. In addition to income effects, the closure of schools, canteens, restaurants, bars and hotels around the world has severely affected food consumption patterns. While precise figures are not currently available, away-from-home consumption of some fruits and vegetables, for example of avocados and pineapples, can account for a substantial share of total consumption in key import markets.⁶ This has most notably been observed in the United States of America and the European Union, where distributors reported difficulties in selling produce, most notably pineapples, throughout the duration of lockdowns.

1.3. Assessing the apparent impact of the COVID-19 pandemic – evidence from global banana and tropical fruit trade

1.3.1 Preliminary market results for 2020/2021

Available trade data and industry information on developments in 2020/2021 suggest that global trade in bananas and the four major tropical fruits proved by and large more resilient to the impact of the COVID-19 pandemic than anticipated at the onset of the outbreak. Especially in 2020, trade flows for several of the commodities in question appeared to continue comparatively smoothly. Full year data for 2020 show that aggregate world trade in

⁶ For example, in France, the largest avocado consuming country in the European Union, one-third of total avocado supply is reported to be consumed out of the home (Dawson, 2020).

the four major tropical fruits expanded by 3.6 percent from 2019, reaching a record volume of USD 9.6 billion in constant 2014–2016 dollar terms. Global exports of bananas, excluding plantain, meanwhile, remained relatively stable at around 21.5 million tonnes in 2020. While this stability of world exports stood in stark contrast with the fast expansion of global banana trade seen between 2017 and 2019, the fact that world exports remained very close to their record level reached in 2019 suggests that banana supply chains proved fairly resilient in 2020, at least in terms of aggregate global exports.

Provisional data for 2021 similarly indicate that, despite significant bottlenecks in global supply chains and rising costs for inputs and transport, the volume of world trade in the four major tropical fruits rose to a record of USD 10.5 billion in constant 2014–2016 dollar terms, marking an expansion of approximately 8 percent from 2020. This overall positive performance was underpinned by abundant supplies from the major production zones, which had invested in production expansion in response to burgeoning global demand and lucrative export opportunities in previous years, resulting in a generally strong availability of produce for export markets in 2021. On the import side, the reopening of the hospitality sector supported demand growth, particularly for avocados and pineapples, in both the United States of America and the European Union, the two main importers. Consumers displayed a higher propensity to spend on nutrient-rich foods, encouraged by advertising campaigns in retail markets highlighting the purported health benefits of tropical fruits. This particularly underpinned rising demand for avocados, whose global exports continued to expand to their historical peak in 2021 despite rising costs of production, transport and marketing along the value chain. Indicative average wholesale prices in the United States of America displayed a tendency to increase for most major tropical fruits, with the exception of pineapples, whose average wholesale prices remained at a low level amid strong pressure along the value chain.

Global trade in bananas, on the other hand, was affected by several factors on both the supply and demand sides in 2021, including the continuing COVID-19 pandemic, weather-related shocks, concerns surrounding the worsening spread of plant diseases, more stringent regulations on maximum residue levels in some major markets as well as slightly lower demand in several import markets. Consequently, it appears that global export quantities fell by some 1.5 million tonnes in 2021. If this estimate is accurate, this fall will be among the largest annual drops in global banana shipments recorded thus far. In view of the ongoing pandemic, the persisting necessity to apply elevated sanitary measures and physical distancing to protect workers from COVID-19 continued to cause additional costs to producers and operators along the supply chain. Industry sources further reported severe difficulties stemming from substantially higher costs for inputs such as fertilizers, whose prices rose by some 30-45 percent, as well as for packaging materials that are vital to industry operations (FreshPlaza, 2021; El-Comercio, 2021). Shortages in refrigerated containers experienced

throughout most of the year alongside substantial rises in global transportation costs posed additional obstacles to export growth and reduced margins along the value chain. In response to these challenges, banana producers and exporters from seven producing countries signed a Regional Agreement for Shared Responsibility in October 2021. This agreement was designed to urge retailers in the key import markets of the European Union, the United Kingdom of Great Britain and Northern Ireland and the United States of America to adjust their prices upward to the benefit of producers and exporters to account for the rising costs of inputs as well as the higher costs associated with strengthening the sustainability of the banana industry.⁷ According to news from November 2021, three companies operating in the North American markets subsequently agreed to raise their prices accordingly, with other market players expected to follow suit (Ecuador Times, 2021), which led to higher reject rates for exports, as produce not meeting these new requirements could not be imported, and the alarming discovery of the Banana Fusarium Wilt Tropical Race 4 (TR4) disease in Peru in April 2021. The plethora of simultaneous difficulties experienced by the sector in 2021 significantly impeded producers' ability to remain operational and especially affected smallholder farmers, and highlight the complexity of risks that global supply chains may face during times of crises.

1.3.2 Medium-term trends in production and trade of bananas and tropical fruits

To facilitate a more thorough understanding of the potential impact of the COVID-19 pandemic on global banana and tropical fruit markets, latest available production data for the major exporters for whom official data were available, were investigated with regard to any potential deviation from their medium-term trend. This evidence provides a background against which the impact of the COVID-19 pandemic on markets can be assessed. At the time of writing, FAOSTAT production data were available up to the end of 2020. One method to assess the degree to which data for these years depart significantly from their normal or expected levels is to inspect the deviation of data for the years available relative to their deviation from trend levels over the previous decade. The results of this analysis showed that for the major producers, only production of pineapples fell below their trend estimates, importantly for Costa Rica and the Philippines. However, a precise assessment of this evidence is rendered difficult given that data for these activities may be subject to substantial annual deviation and trends.

⁷ The signatories to this agreement are, namely, Ecuador, Colombia, Costa Rica, Dominican Republic, Guatemala, Honduras and Panama. On average, these supplying countries account for approximately three-quarters of global exports combined.

2. Investigating the potential implications of shocks to fruit and vegetable value chains – scenario analyzes of bananas and fresh tropical fruits

2.1. Background – the importance of bananas and tropical fruits

Bananas and the four major fresh tropical fruits – mango, pineapple, avocado and papaya – play a vital role in world agricultural production, and especially in securing the nutrition and livelihoods of smallholders in producing countries. In recent decades, income growth and changing consumer preferences in both emerging and high-income markets, alongside improvements in transport and supply chain management, have facilitated fast growth in international trade in these commodities. Against this backdrop, export quantities of the four major fresh tropical fruits have experienced some of the fastest average annual growth among internationally traded food commodities, while export quantities of bananas have increased to unprecedented heights.

Based on 2019 figures, the global banana and major tropical fruit export industries respectively generate around USD 9.1 billion and USD 10 billion per year. Latin America and the Caribbean ranks as the largest banana and tropical fruit exporting region, accounting for the majority of world exports. Ecuador has been positioned as the world's leading exporter of bananas over the past several decades, supplying an average of 5 to 6 million tonnes of this fruit to world markets per year. Although only approximately 15 percent of global banana production and 5 percent of global major tropical fruit production are traded in international markets, in exporting countries, which are mostly low-income economies, revenue from production and trade can weigh substantially in agricultural GDP. For instance, as mentioned above, bananas represented about 42 percent of agricultural export revenue in Ecuador in 2018, and 17 percent in Guatemala. Bananas and tropical fruits further have particular significance in some of the least developed and low-income food-deficit countries,⁸ where they contribute not only to household food security as food items, but also to income and employment generation as cash crops. Research conducted in ten banana producing countries in 2012, for example, revealed that revenue from banana farming can account for some 75 percent of total monthly household income for smallholder farmers (Bioversity, 2012). At farm gate prices of around

⁸ More information can be found on the respective commodity pages of the FAO Markets and Trade Division: www.fao.org/markets-and-trade/commodities/tropical-fruits/en/; www.fao.org/economic/est/est-commodities/citrus-fruit/en/; www.fao.org/economic/est/est-commodities/fruits-vegetables/en/.

USD 300-400 per tonne and typical smallholder yields of 10-15 tonnes per hectare, bananas can generate an estimated USD 3 000 to 6 000 per hectare per year. It is further estimated that approximately 400 million workers rely on income from direct employment in the banana industry globally (FAO, 2019).

Bananas and some of the tropical fruits play a similarly important role in developed country importing markets, where they have either ranked among the most consumed fruits for decades or experienced fast growth in demand in recent years. In terms of leading importers, the European Union and the United States of America absorb over 50 percent of global supplies. The Russian Federation, China and Japan are also significant importers, albeit at significantly lower market shares thus far.

Given the popularity particularly of bananas, pineapples and avocados in import markets, their global value chains have been characterized by intense competition among market actors all the way to the retail level. For bananas and pineapples, this has exerted downward pressure on prices at each stage, which has resulted in producer prices remaining at low levels, with little fluctuation. Combined with rising production costs, low prices and tight profit margins greatly hinder the adequate remuneration of workers and smallholder farmers in these industries and act as a major obstacle for producers in coping with emerging challenges and supply chain disruptions. For all these underlying reasons, it is important to assess the potential impact of shocks on these agricultural commodities.

2.2. Investigating the possible repercussions of shocks – methodological considerations

As shocks occur, all agents in the economy form expectations of how these shocks will affect them and attempt to take responsive action accordingly. A standard partial equilibrium model, such as the FAO Tropical Fruit model, may provide useful insights into the type and magnitude of effects stemming from a variety of shocks. The model encompasses detailed specifications for tropical fruit supply, demand, trade and prices affecting producers, traders and consumers of some 140 countries. This facilitates the analysis of how specific shocks and their subsequent impacts may become distributed in global and national markets compared with the base projections in which the supply shock is absent. For the following analyzes, the baseline projection that was generated for the OECD-FAO Agricultural Outlook 2021–2030 was used as a comparison. The general method of the scenario analyzes was to change specific assumptions contained in the Outlook and compare the modelled outcomes to the base projection.

2. Investigating the potential implications of shocks to fruit and vegetable value chains: scenario analyzes of bananas and fresh tropical fruits

For the purpose of this project, three separate scenarios have been generated to draw out lessons on the potential impacts of shocks and their implications for policy recommendations to strengthen the resilience of supply chains:

- 1.** A partial COVID-19 pandemic scenario that examines the impact of shocks to GDP as estimated by comparing pre-COVID-19 pandemic and post-COVID-19 pandemic projections by the International Monetary Fund.
- 2.** A scenario illustrating the possible impacts of a production shock on supply chains of avocados.
- 3.** A scenario showing the possible impacts of the spreading Fusarium Wilt TR4 disease on banana supply chains.

It should be noted that scenario analyzes of this nature are a simplistic undertaking, not only because the model does not include certain interaction points within the value chain, importantly labour and transport costs, but also because its specification and behavioural parameters are also fixed based on historical evidence and professional judgement. Nevertheless, the model does include anticipated responses by producers, traders and consumers within an accounting, balance and pricing framework that enables indicative market analysis of what would be expected to happen given past experience. The purpose of these scenarios is therefore to provide insight into the reactions that policy analysts may expect to happen as shocks begin to unfold. Comparison ex-post can provide lessons concerning how extreme shocks can deviate from expectations and why.

2.3. A partial COVID-19 pandemic scenario: assessing the potential implications of GDP shocks

Since the beginning of the COVID-19 pandemic, economists have attempted to analyze the possible current and prospective impacts stemming from the global disease spread. As has been often noted, the disease itself has had relatively limited impact on markets. More importantly, it has been the mitigation attempts implemented by citizens, industries and governments to limit or slow the spread of the disease, particularly in the form of mandatory lockdowns, that have had the largest effects on global markets. Amid fast-changing, volatile and highly uncertain conditions, market participants have required ample and timely information to form best strategies to navigate their decisions through the pandemic, be they producers, firms, traders, processors, retailers or consumers. Similarly, policy makers have required evidence-based analyzes to make critical decisions, including on whether and when to mandate lockdowns and whether and which sectors and subsectors to exempt. However,

providing accurate market analyzes during these times has proven particularly tricky. The fact that a threat and disruption of this extent had not been experienced by the world recently has rendered solid conclusions difficult, compounded by the fact that this shock has triggered significant changes in consumer behaviour, preferences, and technologies globally – and potentially within the value chain itself. This has been complicated even more by the wide scope of policy choices in markets such as tropical fruit markets, which are global and interconnected with the economy at various levels, with decisions and events in one country capable of critically affecting outcomes in many others. In this context, it appears useful to examine how expectations concerning market impacts may evolve and differ from eventual outcomes.

2.3.1 Scenario description

A counterfactual scenario using the FAO tropical fruit model was generated to compare the differing impacts between outcomes based on pre-pandemic macro projections, as published by the IMF in the fall of 2019, and those based on the interim-COVID-19 pandemic projections used in the baseline projection, as published by the IMF in the fall of 2020. The purpose of the scenario is therefore to provide a basis for assessing what policy analysts may expect, and how these expectations may evolve as more up to date information on the shock becomes available.

The “interim-COVID-19 pandemic” projection is provided by the base projection undertaken for the OECD-FAO Agricultural Outlook in the spring of 2021, which was conditioned on the macroeconomic projections released by the IMF in October 2020. The macro variables of the model were then replaced by those published in October 2019, before the outbreak of the COVID-19 pandemic. Notably, the major important differences in these variables can be described as a global recession in 2020, which commonly saw GDP fall by about 5-8 percent in 2020 compared to 2019 (Table 1). This also compared to an expected annual growth rate of about 2 percent – i.e. roughly a 7-10 percent difference between the expected and realized GDP levels in 2020. The estimated impact has been generally less for developing countries compared to developed ones. Most notably, while GDP in most countries is projected to return to or exceed their levels of 2019 by 2022, growth anticipated over the medium term has been shifted down, and significantly in some countries such as India.

2.3.2 Scenario interpretation

The main feature of this scenario is the impact of the sudden shock to demand associated with the reduction in GDP in the respective countries in 2020 and its consequences. The product supply response estimated by the model, which, depending on planting and harvesting lags, is to a large extent already determined, does not change much in the first period of the shock. Given the demand and trade elasticities, domestic and international prices are estimated to fall significantly in 2020 compared to the baseline levels, by up to 25 percent (Tables 2 and 3). The decline in prices causes some reduction in crop harvesting and yields, and both global production and consumption fall by between 1 and 3 percent for all crops in 2020 (Table 4 for consumption). Global exports and imports also decline by 1 to 3 percent in the same year (Table 5). After 2020, the first year of the shock, markets converge to a new equilibrium over time with lower production, consumption and trade levels compared to the pre-COVID-19 pandemic projection. This scenario picture presents a reasonably standard view of the impact that a substantive fall in GDP may have on markets.

With time, as new information becomes available, a more accurate indication of the impact that COVID-19 pandemic is having can be assessed. While for a number of reasons it is not appropriate to compare these scenario results to the observed changes, several issues should be addressed. For example, the scenario price impacts for 2020 are generally excessive, and consequently the impacts across the value chain are overstated. The reference prices for bananas (US import prices), for example, were largely unchanged in 2020 over 2019, while those for avocados and pineapples fell by 16 percent and 4 percent, respectively. These actual developments are far less than the estimated scenario impacts which are in the range of -22 to -25 percent for these commodities. On the one hand, it appears that markets are indeed more resilient than was expected. On the other hand, more detailed examination of why this is the case is critical to learning lessons from such expectations. First, while the observed impacts on GDP are generally quite large, many countries implemented income assistance programs, essentially taking up debt to minimize impacts as COVID-19 spread. Second, it is apparent that consumer behaviour also changed with respect to preferences, thus possibly increasing demand for higher nutritive products such as fruits and vegetables. Third, the impact of factors other than income or general economic activity needs to be assessed, including of those along the value chain. These range from harvesting issues, transport logistics and costs, to excess product disposal when price declines make the delivery of products uneconomic. The use of a model, even as basic as the tropical fruit model, enables more detailed adjustments to assess the sensitivity of outcomes to changes in these factors.

Table 1. The COVID-19 pandemic GDP shock as measured by revised GDP projections: October 2019 vs 2020 (percent difference)

	European Union	United States of America	China	India	Japan
2020	-8.4	-5.7	-3.8	-16.7	-6.7
2021	-6.1	-4.5	-1.8	-15.9	-5.2
2022	-4.7	-3.1	-1.8	-15.7	-4.1
2023	-3.9	-2.3	-1.6	-15.8	-3.4
2024	-3.6	-1.8	-1.6	-16.1	-2.9
2025	-3.6	-1.3	-1.7	-16.5	-2.8
2026	-3.7	-0.9	-2.1	-17.3	-2.7
2027	-3.9	-0.5	-2.7	-18.4	-2.7
2028	-4.0	-0.2	-3.5	-19.8	-2.6
2029	-4.3	0.2	-4.5	-21.4	-2.5
2030	-4.5	0.5	-5.6	-23.2	-2.4

Note: Figures shown refer to projections from October 2019 minus those from October 2020 as a percentage of those from October 2019.

Source: OECD/FAO. 2021. OECD-FAO Agricultural Outlook 2021-2030. Paris, OECD Publishing.
<https://doi.org/10.1787/19428846-en>

Table 2. Impact of COVID-19 pandemic GDP shock on US consumer prices (percent difference)

	Banana	Avocado	Pineapples
2020	-14.8	-16.9	-14.9
2021	-14.3	-15.8	-14.7
2022	-9.9	-12.8	-10.9
2023	-3.4	-8.9	-4.4
2024	-3.8	-7.9	-4.5
2025	-8.2	-8.5	-8.4
2026	-10.0	-8.9	-9.7
2027	-8.0	-8.2	-7.9
2028	-4.9	-7.6	-5.3
2029	-4.4	-8.2	-5.4
2030	-6.6	-9.8	-7.3

Note: Figures shown refer to pre-COVID-19 minus COVID-19 pandemic as a percentage of pre-COVID-19 pandemic.

Source: Author's calculations.

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Table 3. Impact of COVID-19 pandemic GDP shock on world reference prices
(percent difference)

	Banana	Avocado	Pineapples
2020	-22.0	-25.2	-22.0
2021	-20.9	-23.3	-21.6
2022	-14.1	-18.8	-15.7
2023	-3.8	-13.0	-5.4
2024	-4.4	-11.3	-5.6
2025	-11.5	-12.0	-11.8
2026	-14.4	-12.6	-14.0
2027	-11.3	-11.7	-11.1
2028	-6.4	-10.9	-7.1
2029	-5.6	-11.9	-7.2
2030	-8.9	-14.4	-10.2

Note: Figures shown refer to pre-COVID-19 minus COVID-19 pandemic as a percentage of pre-COVID-19 pandemic.

Source: Author's calculations.

Table 4. Impact of COVID-19 pandemic GDP shock on global consumption
(percent difference)

	Banana	Avocado	Pineapples
2020	-1.1	-3.2	-1.1
2021	-1.2	-2.4	-1.3
2022	-1.9	-3.0	0.3
2023	-4.0	-3.3	-0.7
2024	-4.1	-4.3	-1.1
2025	-2.3	-6.0	0.3
2026	-1.5	-6.4	0.1
2027	-2.3	-6.0	-0.9
2028	-3.7	-5.3	-1.9
2029	-4.5	-4.9	-2.5
2030	-4.4	-5.1	-2.6

Note: Figures shown refer to pre-COVID-19 minus COVID-19 pandemic as a percentage of pre-COVID-19 pandemic.

Source: Author's calculations.

Table 5. Impact of COVID-19 pandemic GDP shock on global exports (percent difference)

	Banana	Avocado	Pineapples
2020	-2.5	-1.4	-1.9
2021	-1.9	-1.1	-0.2
2022	-2.6	-0.2	-0.5
2023	-4.1	1.2	-2.2
2024	-3.8	0.6	-1.7
2025	-2.4	-1.3	-0.3
2026	-1.8	-2.0	0.0
2027	-2.6	-1.3	-0.5
2028	-3.8	0.0	-1.3
2029	-4.3	0.7	-1.2
2030	-4.1	0.4	-1.1

Note: Figures shown refer to pre-COVID-19 minus COVID-19 pandemic as a percentage of pre-COVID-19 pandemic.

Source: Author's calculations.

2.4. Potential effects of a supply shock in avocado production – indicative scenario results

2.4.1 Baseline projections summary

Avocado has the lowest production level among the major tropical fruits but has experienced the fastest growth in output in recent years and is expected to remain the fastest growing commodity of the major tropical fruits over the outlook period. Production is accordingly projected to reach 12 million tonnes by 2030 – more than three times its level in 2010. Ample global demand and lucrative export unit prices continue to be the main drivers of this growth, stimulating substantial investments in area expansion in both major and emerging production zones. Avocado production has been so far concentrated in a small number of regions and countries, with the top ten producing countries currently accounting for almost 80 percent of global output, but new growing areas are emerging rapidly. Nevertheless, about 74 percent of avocado production is expected to remain in Latin America and the Caribbean, given the favourable growing conditions in this region.

Trade in fresh avocados relative to production is the highest among the major tropical fruits, standing at some 32 percent in quantity terms in the reference period. Avocado trade is also

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the fastest growing, having increased at an annual average pace of 13.1 percent per year between 2011 and 2020. In response to rapidly growing global demand, avocado is expected to become the most traded major tropical fruit by 2030, reaching 3.9 million tonnes of exports and overtaking both pineapples and mangoes in quantity terms. Given the high average unit prices of avocado, the total value of global avocado exports would thus reach an estimated USD 8.3 billion in constant 2014–2016 value terms, thereby placing avocado as one of the most valuable fruit commodities. Latin American countries dominate the export market with 85 percent of export quantities and this share is anticipated to increase to 89 percent over the next ten years. This would be mainly as a result of a significant expansion of the sector in Mexico, the world's largest producer and exporter, which is expected to grow by 5.2 percent per year over the next ten years due to continued growth in demand in the United States of America, the key importer of avocados from Mexico. As such, and despite increasing competition from emerging exporters, Mexico is expected to further increase its share of global exports, to 63 percent in 2030.

Developed countries currently account for 91 percent of total imports, and this share is set to rise slightly over the medium term as their demand is expected to remain firm. As such, the United States of America and the European Union, where consumer interest in avocados is fuelled by the fruit's assumed health benefits, are expected to remain the main importers, with 40 percent and 31 percent of global imports in 2030, respectively. However, imports are also rapidly rising in many other countries such as in China and some countries in the Middle East, and, as measured by the Herfindahl-Hirschman Index of all importers, the concentration of imports is gradually decreasing.

2.4.2 Scenario description – potential implications of a supply shock in Mexico

To facilitate a better understanding of the potential implications of a supply shock for global avocado markets, FAO's model of the global tropical fruit sector has been employed to generate comparative scenario results for 2021. In this scenario, avocado yields in Mexico were reduced by 10 percent relative to their baseline value in 2021. Such a supply shock may occur from adverse weather conditions, including droughts, floods or hurricanes, or from outbreaks of plant pests and diseases. However, in the current scenario the rate of reduction in yields was chosen arbitrarily and for illustrative purposes. The scenario thereby represents a simple way to assess the potential implications of a supply shock, in this case a supply shock in a large producing and exporting country. The results provide an indication of how the subsequent supply shortages may be allocated among markets, including the impact on producer prices, trade, import prices and retail prices in importing markets.

2.4.3 Scenario interpretation

The implications of this assumed 10 percent reduction in yields is a one-time fall in Mexican supplies of approximately 10 percent compared to the baseline in 2021, and, consequently, an increase of 12.5 percent in domestic producer prices for avocados (Table 6). This leads to a decline in avocado exports from Mexico of 13.6 percent compared to the baseline in 2021, and a decline in world avocado exports of approximately 4.8 percent. The change in global trade is less than the reduction from Mexico since prices transmit globally, causing global consumption to fall, and rising exports from competitors to mitigate the change in supply. For example, exports from Peru, the second leading global supplier of avocados, increase by 4.9 percent compared to their baseline. Domestic consumer prices in Mexico increase by 7.7 percent compared to the baseline, and domestic consumption of avocados declines by 5.9 percent. The reduction in the supply to world markets also causes an approximate 10.9 percent increase in world avocado export prices compared to the baseline in 2021. Higher world prices affect import prices in key import markets and subsequent impacts on their respective value chains. For example, the estimated price increase on world markets results in a 4.7 percent decline in 2021 imports by the United States of America, the largest importer of avocados globally, and subsequently in an increase in US consumer prices of 6.4 percent compared to the baseline.

Yields are projected to return to their base levels in 2022. As such, the model indicates that the impact of this one-time supply shock would be largely overcome within the year, causing only minimal diversions from the baseline projections in 2022 and thereafter. A critical conclusion is that open markets help mitigate shocks, which highlights the importance of markets to remain open in times of crises. To consolidate this further, a refined scenario was run in which Mexico applies export restrictions to minimize the impact of the supply shock on its domestic consumers. Table 7 shows the estimated scenario impacts of a 10 percent yield shock in Mexico, combined with a 15 percent export tax put in place by Mexico. The level of the export tax was chosen in order to neutralize the effect of the yield reduction on prices for domestic consumers in Mexico. As can be seen, the export tax reduces the negative effects of the supply shock on domestic consumer prices and domestic consumption but causes substantially larger impact on world markets.

An important point to note is that the magnitude of the impact of the supply shock on global markets is also determined by the relative size of the supplier with respect to world markets. Since Mexico is a large supplier in global avocado trade, supplying some 60 percent of global exports on average, the effects of both the supply shock and export restrictions would weigh more heavily than if the same situation would occur in a smaller market player. To illustrate this, comparative scenario results were generated in which the 10 percent yield shock occurs

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in Peru, which supplies only some 15 to 18 percent of global export quantities on average, i.e. less than a third of the quantities that Mexico supplies to world markets. The results of the respective scenarios are displayed in Tables 8 and 9. These indicate that a 10 percent yield shock in Peru, both on its own and in conjunction with export restrictions, generates significantly smaller estimated effects on world markets.

Table 6. Estimated scenario impacts of a 10 percent yield shock in Mexico on avocado markets

	Mexico QP	Mexico Food Cons	Mexico Exports	World Exports	Peru Exports	United States of America Imports	Mexico Prod Prices	Mexico Consumer Prices	World Ref Prices	United States of America Consumer Prices
2021	-10.0	-5.9	-13.6	-4.8	4.9	-4.7	12.5	7.7	10.9	6.4
2022	0.0	0.0	0.0	0.0	-0.1	0.0	-0.2	-0.2	-0.2	-0.2
2023	0.0	0.1	-0.1	0.0	0.2	0.0	-0.4	-0.3	-0.4	-0.3
2024	0.0	0.3	-0.3	0.2	1.0	0.2	-0.8	-0.5	-0.8	-0.5
2025	-0.1	0.4	-0.4	0.3	1.7	0.3	-0.6	-0.4	-0.7	-0.4
2026	0.0	0.4	-0.4	0.3	1.9	0.3	-0.7	-0.4	-0.7	-0.4
2027	-0.1	0.2	-0.3	0.1	1.0	0.1	-0.3	-0.2	-0.4	-0.2
2028	-0.2	0.0	-0.3	-0.1	0.4	-0.1	-0.1	0.0	-0.1	-0.1
2029	-0.3	-0.2	-0.3	-0.2	0.0	-0.2	0.3	0.2	0.3	0.2
2030	-0.3	-0.3	-0.3	-0.2	-0.1	-0.2	0.6	0.4	0.5	0.3

Note: Percentage change relative to the results of baseline projections in which the supply shock does not occur.

Source: Author's calculations.

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Table 7. Estimated scenario impacts of a 10 percent yield shock in Mexico and a 15 percent export tax on avocado markets

	Mexico QP	Mexico Food Cons	Mexico Exports	World Exports	Peru Exports	United States of America Imports	Mexico Prod Prices	Mexico Consumer Prices	World Ref Prices	United States of America Consumer Prices
2021	-10.0	0.3	-19.0	-6.7	6.7	-6.6	0.0	0.0	15.2	8.8
2022	0.0	0.0	-0.1	0.0	0.0	0.0	-0.2	-0.1	-0.2	-0.1
2023	-0.2	0.0	-0.4	-0.1	0.4	-0.1	-0.2	-0.1	-0.3	-0.2
2024	-0.9	-0.2	-1.6	-0.3	2.0	-0.2	0.1	0.1	-0.1	0.0
2025	-1.4	-0.3	-2.3	-0.3	3.1	-0.3	0.7	0.4	0.4	0.2
2026	-1.6	-0.4	-2.6	-0.4	3.5	-0.3	0.8	0.5	0.5	0.3
2027	-0.9	-0.2	-1.5	-0.2	2.0	-0.2	0.3	0.2	0.2	0.1
2028	-0.5	0.0	-0.8	-0.1	1.1	-0.1	0.0	0.0	-0.1	-0.1
2029	-0.2	0.0	-0.3	0.0	0.6	0.0	-0.1	-0.1	-0.2	-0.1
2030	0.0	0.1	0.0	0.0	0.3	0.0	-0.1	0.0	-0.1	0.0

Note: Percentage change relative to the results of baseline projections in which the supply shock does not occur.

Source: Author's calculations.

Table 8. Estimated scenario impacts of a 10 percent yield shock in Peru on avocado markets

	Peru QP	Peru Food Cons	Peru Exports	World Exports	Peru Exports	United States of America Imports	Peru Prod Prices	Peru Consumer Prices	World Ref Prices	United States of America Consumer Prices
2021	-10.0	-1.7	-13.6	-1.0	1.6	-1.0	3.6	2.3	2.1	1.3
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	-0.1	-0.1	-0.2	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0
2024	-0.6	-0.1	-0.9	0.0	0.2	0.0	0.0	0.0	-0.1	-0.1
2025	-1.0	0.0	-1.4	0.0	0.4	0.0	0.0	0.0	-0.1	-0.1
2026	-1.1	0.0	-1.6	0.0	0.4	0.0	0.1	0.0	-0.1	-0.1
2027	-0.6	0.0	-0.9	0.0	0.3	0.0	0.0	0.0	0.0	0.0
2028	-0.4	0.0	-0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0
2029	-0.2	-0.1	-0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0
2030	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0

Note: Percentage change relative to the results of baseline projections in which the supply shock does not occur.

Source: Author's calculations.

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Table 9. Estimated scenario impacts of a 10 percent yield shock in Peru and a 4 percent export tax on avocado markets

	Peru QP	Peru Food Cons	Peru Exports	World Exports	Peru Exports	United States of America Imports	Peru Prod Prices	Peru Consumer Prices	World Ref Prices	United States of America Consumer Prices
2021	-10.0	0.2	-14.4	-1.1	1.7	-1.0	-0.3	-0.2	2.3	1.3
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2023	-0.2	0.0	-0.3	0.0	0.0	0.0	0.0	0.0	-0.1	0.0
2024	-0.9	-0.1	-1.3	0.0	0.3	0.0	0.1	0.0	-0.1	0.0
2025	-1.4	-0.1	-2.0	0.0	0.5	0.0	0.2	0.1	0.0	0.0
2026	-1.6	-0.1	-2.3	0.0	0.5	0.0	0.2	0.1	0.0	0.0
2027	-0.9	0.0	-1.3	0.0	0.3	0.0	0.1	0.1	0.0	0.0
2028	-0.5	0.0	-0.7	0.0	0.2	0.0	0.1	0.0	0.0	0.0
2029	-0.3	0.0	-0.4	0.0	0.1	0.0	0.1	0.0	0.0	0.0
2030	-0.1	0.0	-0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0

Note: Percentage change relative to the results of baseline projections in which the supply shock does not occur.

Source: Author's calculations.

2.5. Investigating the potential impacts of plant diseases: The spread of TR4 in global banana production and rapid outbreak in South America

2.5.1 Background

The Fusarium wilt disease of banana, scientifically denominated as *Fusarium oxysporum* f. sp. *cubense* is considered among the most destructive of all plant diseases. A soil-borne pathogen, the mycelium and spores of *Fusarium* wilt spread mainly, though not exclusively, through infected plants and planting materials; soil particles attached to shoes, vehicles and tools, and; water, including irrigation, drainage and floods. With its spread facilitated by the monoculture and intensive plantation cultivation techniques and concentrated transport routes of the commercial banana industry, the current strain of the Banana Fusarium Wilt disease, described as Tropical Race 4 (TR4), is presently officially confirmed in 23 banana producing countries, predominantly in South and Southeast Asia. In August 2019, the fungus was detected for the first time on a banana plantation in Latin America, in the north-eastern region of La Guajira, Colombia, and in April 2021 on a farm in Peru. This fourth race of the fungus poses particularly elevated risks to global banana supplies, as it can affect a much broader variety of banana and plantain cultivars than previous strains of *Fusarium* wilt (Ploetz,

2015). In addition, there is currently no effective fungicide or other eradication method that is capable of eliminating TR4. In affected plants, the disease can quickly cause a total yield loss. Due to the longevity of the fungus in the soil, infected land becomes unavailable for banana or any other cultivation for decades, resulting in a shift of production to new, unaffected land as the only recourse. Depending on the severity of the spread, outbreaks can result in an increasing scarcity of pathogen-free soils. In all reported cases, once a farm has been contaminated, managing the disease has proved extremely challenging and costly. This poses a particular threat to the livelihoods of smallholder banana producers in affected regions, who often lack the financial means to sustain operations in the face of simultaneous yield losses and increased production costs. In this regard, prevention, rapid containment and quarantine are particularly important.

The impact of a potential further spread of TR4 Fusarium Wilt was described in an article in FAO's Food Outlook in November 2019 (Altendorf, 2019b). The economic analysis of such an anticipated progression of TR4 was motivated by the first discovery of TR4 in Latin America, the prime global exporting region for bananas. Since the discovery of TR4 in Colombia was deemed a comparatively minor outbreak by leading scientists, the scenario outlined a modest spread of the disease over ten years. However, the discovery of TR4 in Peru in 2021, while considered unrelated to the Colombia outbreak, underscores the ongoing threat that the disease portends for global banana markets.

The scenario conducted in Altendorf (2019b) mapped the impacts of a gradual progression of TR4, and while significant, cannot be considered as estimating the impact of a "sudden shock" to the global banana supply chain. It is not inconceivable, however, that a TR4 shock could result from a number of other possible events. For example, following the example of Australia, where banana imports from the Philippines have been banned, it is conceivable that other Asian countries also suffering from the prospects of a TR4 progression could implement similar bans. Potentially more damaging to global trade could be the sudden spread of TR4 in South America, with further infection in Colombia and Peru extending to Ecuador, the world's largest banana exporter.

2.5.2 Scenario description

A scenario was conducted that maps an assumed progression of TR4 in global banana markets as in Altendorf (2019b), but in which TR4 is assumed to spread rapidly in Ecuador, Colombia and Peru, reducing banana acreage in these countries by half over the full period 2021 to 2030. The effect of this scenario would be a reduction in production area of some 200 000 hectares in key exporting countries over the projection period. While combined production in Ecuador, Colombia and Peru represents only about 9 percent of global banana output, exports from all

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three countries combined constitute over 40 percent of global exports. As such, the sudden reduction of exports from these countries could constitute a major shock to global markets.

2.5.3 Scenario interpretation

The scenario results indicate that world banana trade would be critically and suddenly reduced by the spread of TR4 in key producing countries and especially by the shock to the South American suppliers (Table 10). World exports would fall by 9 percent in the first year, and this would largely continue through the projection period as other suppliers would only replace about 1 percent of lost trade, with the disease spreading to other producing countries. World reference prices for bananas would rise initially by 30 percent, and while they would recover somewhat from the loss of area in South America in subsequent years, the continuing spread of TR4 in other countries would gradually reduce production further over the period, thereby again exerting upward pressure on world prices. Consumer prices, as represented by those in the United States of America, would rise significantly due to the supply shock, although by less than those on international markets, due to marketing margins which are assumed not to change much under the shock. Consumers in all countries with open markets would face rising costs due to higher prices, as market effects would transmit across borders.

The results further suggest that an unmitigated spread of TR4 would entail considerable loss of income and employment in the banana sector in the affected countries, at varying degrees contingent on the internal spread of the disease. Assuming an average of 1.5 workers per hectare, the estimated reduction in harvested area of approximately 200 000 hectares globally would imply the loss of direct employment for around 300 000 banana workers. In affected producing countries, consumer costs could rise significantly as a result of possible border controls designed to protect domestic producers. Meanwhile, producers in unaffected countries would gain from the higher prices induced by the global area losses caused by TR4, and would additionally receive incentives to increase production. Unaffected exporting countries would, correspondingly, capture higher export revenues resulting from higher volumes of shipments at higher unit values.

The scenario indicates the potential costs of a continuous TR4 spread, and its potential to wreak havoc in markets in the short term if it is not monitored and contained successfully. The size of economic damage warrants higher attention for research, which may prevent such events from happening. However, it is important to note that the scenario presented above provides suggestive rather than predictive results regarding the hypothetical market impact of TR4 and should therefore not be interpreted as actual forecasts on the future damage caused by an unmitigated disease progression, but rather as an indicative basis for informing policy decisions.

Table 10. Potential impact of TR4 shock scenario on key global banana market indicators

	World reference price	World production	World Exports	Ecuador exports	Colombia exports	Peru exports	United States of America imports	European Union imports	United States of America Consumer price
2021	30.2	-3.4	-9.2	-49.2	-63.9	-52.9	-6.5	-6.0	17.4
2022	27.2	-2.8	-8.9	-49.4	-64.2	-53.6	-6.0	-6.0	15.8
2023	20.2	-1.8	-8.1	-49.7	-64.8	-54.3	-4.7	-5.5	11.9
2024	15.2	-1.2	-7.4	-49.9	-65.6	-55.0	-3.7	-5.2	9.0
2025	18.4	-1.7	-7.5	-49.8	-65.3	-55.8	-4.1	-5.8	10.8
2026	25.8	-2.8	-8.1	-49.4	-64.4	-56.5	-5.5	-6.7	15.0
2027	29.2	-3.3	-8.2	-49.3	-64.0	-57.2	-6.1	-7.2	16.9
2028	27.5	-3.1	-7.7	-49.3	-64.4	-57.9	-5.9	-7.1	16.0
2029	25.3	-2.8	-7.1	-49.4	-64.9	-58.6	-5.4	-7.0	14.7
2030	26.5	-2.9	-6.9	-49.3	-64.9	-59.3	-5.5	-7.2	15.4

Note: Figures refer to the ratio of the scenario results minus the baseline results as a percentage of the baseline results.

Source: Author's calculations.

2.5.4 Mitigating the threat of TR4

The simulation results suggestively illustrate the likely far-reaching repercussions that an unmitigated spread of TR4 would have on global banana markets. The underlying postulations of the simulation assume a medium-spread scenario, implying that the potential impact on world banana supply and world banana markets could translate into significantly larger effects should the disease spread more rapidly or further afield. In particular, given the importance of the Latin America and the Caribbean Region in global banana exports, the specific outcome of the impact on global markets would hinge on whether the recent outbreaks of TR4 in Colombia and Peru can be contained or not. In the best-case scenario, the disease would not spread further, resulting in no significant impact on global markets diverging from the projections presented here over the next decade. In the worst-case scenario, a wide spread of TR4 in Latin America and the Caribbean would have a considerable economic impact on trade, food security and the economic wellbeing of producing countries in the region, as well as on producers in other exporting countries and consumers in importing countries.

The potential repercussions of infection by TR4 are of even greater concern to organic banana production, since organic agricultural practices do not permit genetic modifications, leaving classical breeding of disease-resistant cultivars as the only option for adaptation. This would be particularly alarming for Ecuador, the main producing country of organic bananas

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that borders Colombia and Peru. In view of the wide-ranging potential ramifications on both conventional and organic banana markets, the recent outbreaks of TR4 in Colombia and Peru necessitate elevated vigilance in the banana sector, not only in Latin America and the Caribbean, but also globally. The expertise of a leading plant pathologist suggests that future banana production may only become viable for growers who are able to implement more advanced management techniques and financially sustain significantly higher investments into disease prevention.⁹

Governments of producing countries have a key role to play in mitigating the spread of TR4 and managing the disease where it has already emerged, particularly in view of its potential impact on smallholder banana farmers and workers employed in the industry. Close coordination of the capacity-development and extension activities of all concerned national institutions will be beneficial to the development of proper policies, regulations and strategic measures that address the challenges of TR4 in a comprehensive way. Strong National Plant Protection Organizations (NPPO) with a defined action plan, legal framework and procedures on prevention, preparedness, detection, response and recuperation reduce the risk of a potential incursion and its socio-economic impact. The recent experience in the Republic of Colombia shows that the coordination and collaboration between the NPPO, the private sector, research centres, technicians and producers, as well as the different sectors of civil society is essential to achieve good results in the detection, containment and management of this disease. The phytosanitary measures applied for the containment of the outbreak by the Colombian Agricultural Institute (ICA) have prevented the spread of the pest to other production areas in the country and facilitated the declaration of disease-free zones, reducing the potential negative impact on production and exports. In addition, national support schemes drawn up in strategic collaboration with different stakeholders and designed to assist in the implementation of adequate biosecurity measures, as well as in the facilitation of diversified production systems that have shown to be less susceptible to TR4 infection than mono-cropping systems, may also serve as responses that can alleviate the problem. Such compensating or support schemes may further contribute to containment of the disease, by easing the moral hazard problem of farmers not reporting and not treating infected plantations properly.

⁹ Personal communication with Dr Charles Staver, Bioversity International.

3. Conclusions and potential implications

Disruptions to trade and uncertainties in global markets can pose particular difficulties for those producing countries whose agricultural GDP relies heavily on the foreign exchange earnings generated by exports of fresh fruits and vegetables. These risks are particularly pronounced in many major banana and tropical fruit exporting countries, where producer margins tend to be under significant pressure due to a number of factors, including highly competitive value chains, the intensifying market power of downstream actors, the occurrence of plant diseases, and adverse weather events compounded by climate change.

In view of the unprecedented magnitude of recent supply chain disruptions, their uncertain duration and complex effects on economic growth and food security, it is critical to develop policies aimed at providing financial support to producers so that they can remain operational, while protecting the health and safety of workers and minimizing disruptions to national and international transport routes. Such strategies will be essential to ensure that supply chains for fresh fruits and vegetables continue to operate in a sustainable manner, for the benefit of producers, market operators and consumers alike.

Markets and open trade display considerable potential to mitigate global economic costs of supply chain disruptions, given the role of trade as a balancing force between supply and demand. As described in the TR4 scenario, higher production in unaffected countries would largely compensate for lower production in affected countries. However, both national and global welfare costs can only be efficiently contained if open trade is maintained. Taxing exports would rapidly raise the economic costs of supply shortfalls in international markets. Strengthened international collaboration, particularly with regards to trade policy as well as enhanced data collection and information sharing on aspects such as the costs of sustainable production and the role of labour along the supply chain, are key to supporting transparency in global trade and to strengthening the preparedness of the global system to crises.

Ensuring that growth in trade is inclusive and equitable and has the potential to generate substantial income gains to smallholder producers, as well as significant export earnings for many of the producing countries, may help to mitigate the damaging consequences of crises. Considering the uncertain and highly volatile outlook for global food supplies, inflation and prices, consumers' ability to afford healthy diets threatens to be direly affected in both producing and importing countries, contingent on people's access to savings, credit and social safety net programmes. Low- and middle-income countries, in particular low-income food-deficit countries, which may lack the capacity and funds to implement effective social protection programmes and economic stimuli, are especially at risk, alongside net food importing

countries. Rising inequality globally, including in high-income countries, is of further concern. Protecting consumers, particularly the most vulnerable, from nutritional deterioration requires concerted action at national and global level, possibly including, as already deployed in many instances, the suspension of bilateral loan repayments and collaboration with international creditors on the release of emergency funding. This suspension could be considered as a temporary measure that would apply only in exceptional situations of emergency to protect food security. It would need to be designed in consultation with international creditors. Strengthened availability, accessibility and affordability of nutrient-rich fruits and vegetables on a global scale can be conducive to improving the nutritional quality of diets. This nutritional dimension is especially important in light of the globally rising incidence of malnutrition in its various forms and the increasingly heightened importance of healthy immune systems.

The findings and evidence indicate that markets appear to be fundamentally resilient and adaptive to shocks. However, the impact of shocks on market agents, in time and in space, depends on a wide variety of factors depending on the type, duration and location of the shock, and fundamentally on the nature or structure of the market involved. Supply shocks originating from weather-induced yield shortfalls in a particular country or region are probabilistic in nature and can be somewhat assessed from historical experience although climate change is expected to modify the weather pattern. Supply shocks due to spreading plant diseases can be sudden but can often be anticipated to some degree once they have been initially identified in one country or region. Systemic shocks, such as that experienced in the COVID-19 pandemic which may be sudden, large, global and largely unexpected, are much more difficult to mitigate. In each of these different cases, measures to abate the size of the shock and its incidence on market agents may be quite different.

All market agents need timely and accurate market information to be able to adjust their strategies as shock conditions unfold. Policy makers need tools to anticipate market reactions and to design policies that adequately accommodate how such reactions may affect market outcomes. If models capture our understanding of how markets work in terms of stylistic specifications of behaviour throughout the marketing chain (however naïve this may seem to be) then it indicates during shocks that the actual specifications of those models need to be adjusted or refined to anticipate how agents respond during crises. Models such as the global tropical fruit model are general in nature and not able to capture detailed reactions throughout the entire supply chain. For example, in the case of the COVID-19 pandemic scenario, the model's limitations do not allow for a detailed assessment of the simultaneous shocks on labour supply and transport costs that occurred alongside the shock to GDP. However, given the evidence on which the models are based, they are able to indicate rough magnitudes of how significant various types of shocks affect market agents. Further investigation of the

combination of demand and supply side shocks that lead to the unique impact of COVID-19 pandemic, including the unanticipated price movements it caused, would generate additional evidence. In this regard, the various effects could be explored to some extent by describing and examining more complex scenarios with multiple assumptions on the quantitative characterisation of these various shocks. Areas for further research could include a detailed investigation of how foreign exchange effects may influence outcomes in the face of shocks. In this regard, it would be interesting, for example to look at how exporters were affected by the downturn in export demand and to investigate whether they found marketing opportunities in domestic markets, for example, as happened in some coffee exporters. Such analysis, however, would be contingent on data availability.

From the scenarios conducted, some tentative lessons can be drawn:

- From the shock to Mexico/Peru avocado yields, it can be understood that market size (i.e. export quantities and export shares) matters. With climate change, yield shocks may increase in frequency and intensity. Growing market concentration in export industries or increasing concentration for imports may be a concern for large importing countries. Furthermore, the introduction of an export tax by the government of an exporting country to mitigate domestic price increases for its consumers should be discouraged.
- From the COVID-19 pandemic GDP shock scenario, it can be learned that market models can help to diagnose critical behavioural points and how they may affect market outcomes as they evolve. This may help evaluate how important certain policy actions could be in affecting outcomes. For example, measures to minimize supply disruptions as well as the impacts of such shocks would be critical. Such measures may involve producer support programmes, protection for health and safety, maintaining transport routes and keeping borders open and wholesale/retail markets functioning.
- From the Banana TR4 disease spread scenario, illustrative projections of the economic costs and the incidence of production losses can provide motivation to finance research and monitoring activities as well as other types of preventative measures and rapid-response systems to limit disease spread. This can help shocks of this nature to be prevented from occurring in the first place or be minimized in their impact.
- In the case of perishable items such as fruits and vegetables, investments in infrastructure and improved cold chains can help to ensure that produce can move smoothly from production to market and provide more resilient market integration for remote production areas and smallholder farmers.
- Advanced cold chain technologies as well as the application of bio coatings that may extend the post-harvest shelf life of produce may further facilitate more steady market opportunities.

Strengthening the resilience of agricultural supply chains

The case of fresh fruits and vegetables

- Investments in drying and processing facilities that would enable excess supply of fresh fruits and vegetables to be processed and preserved for later marketing may further strengthen the resilience of the industry during times of supply chain bottlenecks. This may not only alleviate the potential losses associated with the high perishability of fresh fruits and vegetables, but also improve farmers' income opportunities through value addition.

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