On the Effects of the COVID Epidemic on Global and Local Food Access and Availability of Strategic Sectors: Role of Trade and Implications for Policymakers

Fabio G. Santeramo and Ignacio Perez Dominguez

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On the effects of the COVID epidemic on global and local food access and availability of strategic sectors: *role of trade and implications for policymakers*

Fabio G. Santeramo[a] and Ignacio Perez Dominiguez[b]

[a]*University of Foggia, Italy*
[b]Joint Research Center of the EU Commission, Spain

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Executive summary

The **COVID-19 pandemic** has **caused** and continues to cause considerable economic hardship, with significant **pressures on all agri-food markets**, including the Fruit and Vegetable (F&V) sector. **Several determinants**, such as social distancing measures, international restrictions on travel and immigration, and an international price war in crude oil, have **affected economic activities in North America and Europe**, **with effects on price dynamics** of agri-food products and, in particular, of perishable and **high-value products, such as F&Vs**.

The study explores how the pandemic has influenced the **prices of F&Vs** in **Canada**, the **United States**, **Mexico**, and the **European Union (EU)**, and how these changes have been reflected in food access and food availability via trade.

First, we aim at understanding how the pandemic has affected both the level and variability of F&V prices in selected countries, and how changes in trade have contributed to these dynamics (***positive analysis***). This goal is achieved by analysing price series over the periods March to June in 2019 and 2020. We show that in the **United States and Mexico, price levels and variability tended to surge**, while the opposite was true for Canada. In the **EU**, while **price levels increased, price variability decreased,** with a few exceptions (i.e., Portugal, France, the Netherlands). We found a **marked increase in the prices of fruit and nuts**, but not of vegetables, roots, and tubers. Our results also show that the less perishable the type of F&V, the higher the impact on prices: this tendency was evident in the **Canadian, U.S., and EU markets**, which **experienced hoarding during the pandemic**, as consumers, worried by the prospect of shortages in food stores, overbought non-perishable commodities.

Second, we investigate how the policies implemented to limit the contagion and resulting economic crisis have influenced price dynamics of F&Vs (***normative analysis***). We review policy measures and actions that have been implemented. The increase in the price levels and price variability of F&Vs has been limited by announcements of unprecedented government stimulus packages in Canada (i.e., improved access to credit for agri-food operators, among many other actions), the United States (e.g. Coronavirus Food Assistance Program), and some EU countries (e.g. support to local producers of F&Vs in Italy, Portugal, and Romania; establishment of a green corridor allowing for mobility of guest workers across EU borders).

Third, we assess how different and spatially separated markets of more/less perishable and seasonal produce, such as F&Vs, have performed in terms of resiliency to the pandemic (***comparative analysis***). We compare price differences across markets. While **U.S. markets** seem **more integrated**, in **Canadian and Mexican markets**, **price differences have increased** during the pandemic, and markets appear less integrated. In the **EU**, polar cases are frequent: differences in price pairs are somewhere near null, but in **countries most hit by the pandemic** (Italy, Spain, and France), **markets have become less integrated**.

The **challenges for the F&Vs sector** are mostly related to **labour availability** and decisions on **trade policies**. Efforts should be devoted to **lower trade barriers** for the **commodities most affected by** the economic effects of the **pandemic**, such as F&Vs.

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Acronyms

2019-nCoV	Novel coronavirus outbreak
C$	Canadian dollar
CAN	Canada
CFAP	Coronavirus Food Assistance Program
COVID-19	Coronavirus disease 2019
CZK	Czech Koruna
EUN	European Union
FAPDA	Food and Agriculture Policy Decision Analysis Tool
FAO	Food and Agriculture Organisation
FCC	Farm Credit Canada
F&Vs	Fruit and vegetables
GDP	Gross Domestic Product
HORECA	Hotel, restaurant, and catering
HRK	Croatian Kuna
IMF	International Monetary Fund
ITA	Italy
MERS	Middle East Respiratory Syndrome
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries
PHEIC	Public Health Emergency of International Concern
PNL	Polish Zloty
SARS	Severe Acute Respiratory Syndrome
US	United States
US$	US dollar
USA	United States
USDA	United States Department of Agriculture
WHO	World Health Organisation

1. Introduction

1.1. Background and motivation

The COVID-19 outbreak started in China during the winter of 2019-20 and rapidly became a pandemic. Within a month of its recognition,[1] COVID-19 spread worldwide, with major epidemics occurring not only in China, but also in Europe, the United States (US), and many other parts of the globe.

According to recent data from Worldometers, COVID-19 is affecting 213 countries and territories around the world, with more than 20 million COVID-19 cases and over 700,000 deaths.[2] The economic impact of the pandemic is forecasted to be enormous: the IMF (2020) declared that "the global economy is projected to contract sharply by –3 percent in 2020, much worse than during the 2008–09 financial crisis".

The COVID-19 pandemic has showed how rapidly new infectious diseases can spread. To slow the contagion and to reduce the fatality rate associated with COVID-19, entire cities and regions have faced, or are still facing, shutdowns. Under these conditions, economists and policymakers are concerned about the economic costs resulting from the restriction of movement placed on the affected countries (Vos et al., 2020).

Fears of shortages are growing in the food system, where the measures used to contain the diffusion of COVID-19, such as trade and border restrictions and regional lockdowns, have the potential to disrupt food supply chains (Glauber et al., 2020). As reported in Torero (2020), food producers in the United States and Canada have lost a large share of their demand, especially for dairy products, due to the closure of hotels and restaurants;[3] Peruvian producers have wasted tons of white cocoa for similar reasons; farmers in India, who cannot move fruit from fields to city markets, are feeding strawberries to cows; fruit and vegetable (F&V) markets in Europe may experience increases in prices, due to a combination of demand shifts and intra-EU and extra-EU trade frictions (Cioffi et al., 2011); and slaughter houses in the United States may experience a shortage of workers and a slowdown of demand growth.

Containment measures have also had a negative impact on the availability of labor. Seasonal farmworkers and migrant workers usually employed in the harvesting and handling of crops are unable to travel due to regional lockdowns, leading to the decay of some crops in the fields (Glauber et al., 2020; Torero, 2020).

The effects of containment measures are likely to differ across supply chains. While for key staples such as wheat or rice, stocks and production may be not damaged and prices will tend to stabilize, perishables are more vulnerable (Glauber et al., 2020), with effects that are likely to be transmitted along the entire supply chain (Santeramo and von Cramon-Taubadel, 2016). F&Vs are severely exposed to disruption (OECD, 2020) due to seasonal labor requirements and high perishability (Tamru et al., 2020). If unable to reach wholesale markets in a timely manner, F&Vs will often go to waste (Torero, 2020).

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[1] On January 30, 2020, the World Health Organisation (WHO) declared the novel coronavirus outbreak (2019-nCoV) a Public Health Emergency of International Concern (PHEIC). The WHO reported a total of 7,818 confirmed cases worldwide in January 2020: most of these cases were in China, with a few detections in 18 countries outside of China (WHO Timeline - COVID-19).

[2] It is important to note that the COVID-19 situation is evolving rapidly: as a result, the numbers indicated are to be considered as representative of the situation in early August 2020.

[3] However, the contraction of demand by the hotel, restaurant, and catering (HORECA) sector for high-value food products (dairy products and meat) is making high-value products less valuable, and such a situation makes unclear the direction price changes.

Trade normally allows production to move from surplus to deficit regions, but with countries and regions experiencing the pandemic at different times, national governments are likely to act without coordination and adopt protectionist policies such as tariffs and export bans in response to the pandemic. This approach was adopted by Russia to limit wheat exports for three months and ensure self-sufficiency (Torero, 2020). Such restrictive measures may increase food prices and generate uncertainty for producers and consumers (FAO, 2020). Alternatively, Brazil provided for a temporary tariff suspension[4] to facilitate rice purchases from abroad. A deeper analysis corroborated with trade statistics and interventions on trade (e.g. Argentina and Ukraine are limiting trade) seems necessary.

Monitoring food prices during crisis is of utmost importance to avoid or contain supply chain disruptions and shortages. Past experiences with viral outbreaks—such as severe acute respiratory syndrome (SARS), avian influenza, and Middle East respiratory syndrome (MERS)—have shown that prices may increase during such outbreaks (Hernandez et al., 2020; Vos et al., 2020).

Price dynamics are erratic within countries, especially when the contagion is spread in a very heterogeneous way, both spatially and across time. In fact, the intertemporal surge levels may also amplify the price dynamic volatilties. Emblematic cases were reported in Italy, where a large share of the contagion was located in a single region (Lombardia), and the US, where a vast majority of cases during the first wave were detected in the metropolitan area of New York City.

The impacts of the COVID-19 pandemic on food availability—due to reduced inter-regional and intra-national trade and erratic price dynamics—may be severe and call for deeper investigation and policy reflections to guide policymakers in this delicate recovery phase.

The price effects of the pandemic are likely to be linked to several factors, including:

i. Supply disruptions, due to higher morbidity, lack of temporary workforce from abroad, and logistical problems;
ii. Demand disruptions, e.g. collapse of the hotel, restaurant, and catering (HORECA) sector;
iii. Trade disruptions due to potential protectionist measures by major food producers;
iv. Loss of wealth and increased income inequalities due to the economic crisis;
v. Spill-over effects from energy markets on biofuels markets, generated by a decline in transport activity.

These factors have been considered to offer recommendations for policymakers.

1.2. Proposed objectives and methods

Based on the context described above, the report shows how the COVID-19 pandemic has affected food availability of strategic sectors, such as F&Vs, in different countries.

The availability of F&Vs is likely to be affected significantly by the pandemic due to the inadequate availability of seasonal workers and the perishability of produce. The analysis deepens our understanding of how the pandemic has affected the prices of more perishable and less perishable F&Vs in Canada, the US, Mexico, and the EU, and how these impacts are reflected in food access and food availability at the regional and global levels.

[4] Rice imports from countries outside the Mercosur bloc (Argentina, Brazil, Paraguay, and Uruguay), such as the United States, faced a 12% import duty on milled rice and a 10% duty on paddy rice.

The study has three goals:

1. To explore how the pandemic has affected F&V prices (price levels and price variability) in selected countries, and how changes in trade have contributed to these dynamics (*positive analysis*);
2. To examine how the policies implemented to limit the contagion and the economic crisis (i.e. trade restrictions) have influenced price dynamics of F&Vs (*normative analysis*);
3. To assess how different and spatially separated markets (of more/less perishable products and of more/less seasonal products) have performed in terms of resiliency to the pandemic (i.e., price stability, welfare redistribution). Based on this analysis, we draw conclusive lessons on how policymakers may promote, also via intra-regional and interregional trade, food access and food availability at the regional level and foster the functioning of markets (*comparative analysis*).

The first goal is achieved by analysing descriptive statistics of the price series. The second goal is reached through a detailed analysis of policy measures and urgent actions implemented to limit the effects of the pandemic. The third goal is achieved through a comparative analysis of prices differences across markets. The study requires price data at a high level of disaggregation, collected during the first part of the analysis.

2. Data collection and sample description

Our case studies are Canada, the US, Mexico, and the EU. North America and Europe have been severely affected by the COVID-19 pandemic (see Appendix A.1 for further details). The first COVID-19 cases were reported in the US on January 19, 2020 and in 7 EU countries (16 in Germany, 12 in France, 3 in Italy, 2 in Spain, and 1 each in Belgium, Finland, and Sweden) on January 21, 2020. The COVID-19 outbreak spread in Europe with some differences across Member States: Spain, Italy, France, and Germany were among the more affected (over 200,000 cases per country), while Greece, Hungary, and Croatia were less affected (less than 10,000 cases each). During the period March-October 2020, contagions in Europe and Canada seemed to be contained (maybe due to heavy policy intervention), but in the US and Mexico, the pandemic continued to evolve, and the curve of infections showed little signs of abating.

We observe price dynamics in the F&V sector from January 2019 to June 2020 in different markets in Canada (Montreal and Toronto), the US (Atlanta, Baltimore, Boston, Chicago, Columbia, Dallas, Los Angeles, Miami, New York, Philadelphia, Rotterdam, San Francisco), and Mexico (Guadalajara, Mexico City, Monterrey), and from January 2019 to May 2020 in selected EU markets (Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Spain). F&V production has a prominent role in the selected countries. According to FAOSTAT data, in 2018, F&V production amounted to 133.4 million of tonnes in the EU, 57.8 million tonnes in the US, 38.9 million tonnes in Mexico, and 3.4 million tonnes in Canada.

The study requires price data at a high level of disaggregation that were collected during the first part of the analysis (about 1 month): daily wholesale prices for F&Vs (different varieties and origins) for Canada, the US, and Mexico and monthly prices for the EU. Details are presented in table 2. The data were drawn from the Government of Canada (Market Analysis and Information, Section Horticulture and Cross Sectoral Division, Agriculture and Agri-food Canada) for Canada, from the U.S. Department of Agriculture's Agricultural Marketing Service (USDA/AMS) for the US and Mexico, and from Eurostat for the EU.

Following Pennington and Fisher (2009), we classified F&V commodities into the categories of vegetables, roots and tubers, and fruit and nuts and separated them from legumes and other horticultural products (e.g. flowers, herbs). We also considered seasonal differences according to the Seasonal Produce Guide (USDA, 2020), and we further classified F&V commodities by their perishability: high-perishable (up to 1 month), medium-perishable (1-6 months), and low-perishable (more than 6 months),[5] following Kader (2020). We collected shelf-life data for F&V commodities from Gross et al. (2016) and considered the optimum storage conditions (by temperature or controlled atmosphere) to assign grades of perishability to F&V commodities.

Import and export monthly data at the two-digit level of the Harmonised System classification (HS 2-digit) were collected from UN Comtrade for the following categories: Edible vegetables and certain roots and tubers (HS 1996: 07), Edible fruit and nuts (HS 1996: 08), and Beverage (HS 1996: 22).

Information on urgent policy measures implemented by governments to limit the socioeconomic impacts of the pandemic was retrieved from the Food and Agriculture Policy Decision Analysis Tool (FAO's FAPDA database).

[5] Table A.1 in Appendix A.2 lists commodities according to their perishability.

Table 1. Price data availability for Canada (CAN), the United States (USA), Mexico (MEX) and the European Union (EUN).

	CAN	USA	MEX	EUN
Markets	Montreal, Toronto	Atlanta, Baltimore, Boston, Chicago, Columbia, Dallas, Los Angeles, Miami, New York, Philadelphia, Rotterdam, San Francisco	Guadalajara, Mexico City, Monterrey	Austria, Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Spain
Products	Fruit and vegetables, different varieties and origins	Fruit and vegetables, different varieties and origins	Fruit and vegetables, different varieties and origins	Fruit and vegetables
Wholesale price	US$	US$	US$	€/100 kg net weight
Frequency	Daily	Daily	Daily	Monthly
Source	Canada Government	United States Department of Agriculture (USDA)	USDA	Eurostat

3. Methodological approach

The study relies on three types of analysis: positive, normative, and comparative.

3.1. Positive analysis

To understand how the pandemic has affected F&V prices, we investigate the properties of the price series.

We compare average prices (levels) and average deviations between minimum and maximum levels of monthly prices (variability) between the periods of March-June 2019 and March-June 2020 for Canada, the US, and Mexico and between March-May 2019 and March-May 2020 for the EU. Given the data availability, the selected timeframe allows us to understand if price dynamics were affected during the pandemic from March to June 2020.

For each market in the selected countries, we derive the percentage of products reporting an increase in price level and price variability between the two selected periods. We also compute the median variation in price levels and volatility across the two periods for products reporting a price increase and for products reporting a price decrease.

We highlight common and localised behaviours in price levels and volatility of commodities across markets. We observe common behaviours for more than 75% of the markets studied and localised behaviours in less than 25% of the markets. These analyses are performed on different classifications of commodities (i.e. fruit and nuts *versus* vegetables, roots and tubers; commodities marketed in seasons within the pandemic *versus* commodities marketed in seasons out of the pandemic; different grades of perishability). Price dynamics are also compared to the values of monthly imports and exports in 2019 and 2020.

3.2. Normative analysis

To understand how policies implemented to limit the contagion and the economic crisis have influenced the price dynamics for F&Vs, we analyse policy measures and urgent actions implemented in each country to limit the socioeconomic effects of the pandemic. These policy interventions and urgent measures are classified according to the dates when these measures took effect. After the beneficiaries of each intervention are identified, measures intended to support the agri-food sector are selected and examined. We also compare the degree of policy interventions and price level and deviation in selected countries between March-June 2019 and March-June 2020.

3.3. Comparative analysis

To assess how different and spatially separated markets of more/less perishable produce and of more/less seasonal produce performed in terms of resiliency to the pandemic (i.e. price stability, welfare redistribution), we compute absolute differences in F&V prices between market pairs for the periods March-June 2019 and March-June 2020. This analysis allows us to reflect on the efficiency of intra- and inter-regional food access and food availability, and on the functioning of markets in the countries studied.

4. Positive analysis

We compare prices between March-June 2019 and March-June 2020 for Canada, the US and Mexico, and between March-May 2019 and March-May 2020 for the EU.[6] The results are reported in table 3 for each market studied.

The US and Mexico tended to report a surge in prices (both level and volatility); the opposite is true for Canada. In the EU, while price levels generally increased (from +4.84 $, + 5%, in Croatia to +36.92 $, + 20%, in France), deviations in prices tended to decrease, with the exceptions of Portugal (+12.95 $), France (+11.02 $), and the Netherlands (+27.87 $).

Marked differences exist across markets in each country. For instance, Mexico City is the most affected market in Mexico, with an increase of 9.26 $ (+90%) in price levels from March-June 2019 to March-June 2020 and a deviation in prices in March-June 2020 more than 300 times larger than in March-June 2019 (from 0.86 $ to 31.43 $). It is important to note that the pandemic in Mexico started to spread late in April and was still underway as of July 29, 2020, with Mexico ranked 6th in the list of most affected countries (see fig. A.3 in Appendix A.1.3).

In the US, a few markets reported a reduction in price level (i.e., Atlanta, Miami, San Francisco), while other markets showed an increase, with the most affected being Rotterdam in terms of price level (+1.85 $, +15%) and New York in terms of price deviation (+2.97 $). The State of New York (New York City, Rotterdam) also is one of the US States most affected by COVID-19, with a total of 442,060 cases as of July 29, 2020 (see Appendix A.1.2). In each country, marked differences also exist across products and markets. A detailed analysis is reported in the next sections.

[6] As a preliminary analysis, we analyse the Producer Price Index (PPI) of F&Vs in selected countries over the period 2000-18 to control for trends in price levels. Data are from FAOSTAT. The average variation in annual PPI of F&Vs in each country differs from the average variation in prices observed between 2019 and 2020. The average variation is 2.41% during 2000-18 and -0.64% during 2019-20 in Canada, 5.55% during 2000-18 and 3.72% during 2019-20 in the US, 2.58% during 2000-18 and 69.61% during 2019-20 in Mexico, 3.22% during 2000-18 and 15.63% during 2019-20 in the EU.

Table 2. Trends in F&V price level and deviation in selected countries.

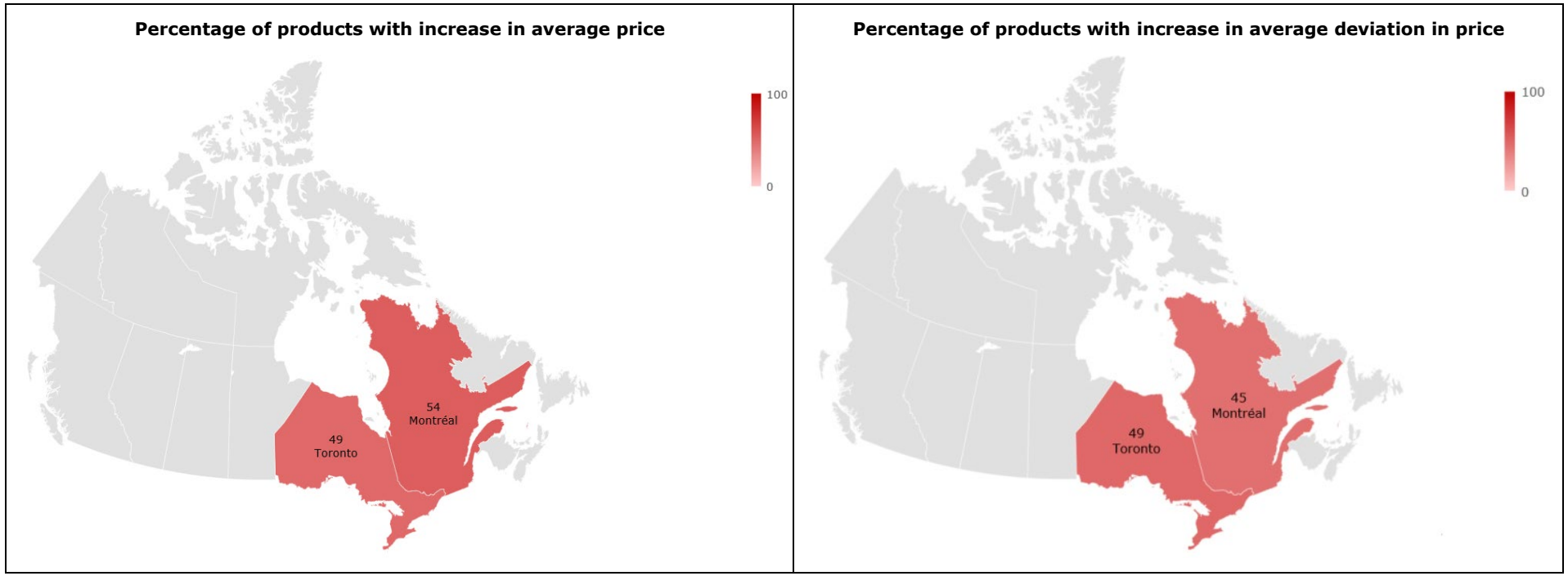
	Average prices			Average deviation		
Canada	March-June 2019 ($)	March-June 2020 ($)	Variation ($)	March-June 2019 ($)	March-June 2020 ($)	Variation ($)
Montreal	33.79	33.73	-0.06	3.00	2.73	-0.27
Toronto	37.52	37.11	-0.41	2.94	1.95	-0.99
United States	March-June 2019 ($)	March-June 2020 ($)	Variation ($)	March-June 2019 ($)	March-June 2020 ($)	Variation ($)
Atlanta	28.08	26.96	-1.12	1.89	3.21	1.32
Baltimore	27.48	28.62	1.14	1.06	3.14	2.08
Boston	25.92	26.54	0.62	0.45	1.14	0.69
Chicago	28.01	28.10	0.09	1.09	1.80	0.71
Columbia	26.63	27.66	1.03	4.09	6.20	2.11
Dallas	37.41	39.74	2.33	0.93	3.80	2.87
Los Angeles	25.10	28.37	3.27	0.81	2.16	1.35
Miami	23.70	23.22	-0.48	0.34	1.12	0.78
New York	24.53	26.50	1.97	0.48	3.45	2.97
Philadelphia	24.87	25.69	0.82	1.57	3.59	2.02
Rotterdam	12.33	14.18	1.85	1.91	2.46	0.55
San Francisco	29.29	27.61	-1.68	3.09	0.83	-2.26
Mexico	March-June 2019 ($)	March-June 2020 ($)	Variation ($)	March-June 2019 ($)	March-June 2020 ($)	Variation (%)
Guadalajara	12.89	19.30	6.41	1.70	29.64	27.94
Mexico City	10.92	20.18	9.26	0.86	31.43	30.57
Monterrey	8.49	14.79	6.30	1.27	19.36	18.09
European Union	March-May 2019 (€)	March-May 2020 (€)	Variation ($)	March-May 2019 (€)	March-May 2020 (€)	Variation ($)
Austria	56.68	79.94	23.26	8.39	6.30	-2.09
Belgium	94.74	113.63	18.89	61.84	28.61	-33.23
Bulgaria	128.48	140.54	12.06	69.81	52.35	-17.46
Croatia	78.59	83.43	4.84	34.90	27.01	-7.89
Czech Republic	60.58	80.78	20.20	31.76	1.45	-30.31
France	183.80	220.72	36.92	13.47	24.49	11.02
Germany	78.77	94.70	15.93	59.53	52.07	-7.46
Greece	101.66	118.21	16.55	16.46	12.18	-4.28
Hungary	129.04	124.28	-4.76	43.73	27.50	-16.23
Ireland	299.56	308.37	8.81	0.00	0.00	
Italy	125.72	138.16	12.44	44.24	26.50	-17.74
The Netherlands	119.81	151.03	31.22	70.11	97.98	27.87
Poland	51.57	80.30	28.73	46.92	33.34	-13.58
Portugal	92.80	87.60	-5.20	14.89	27.84	12.95
Romania	63.29	61.85	-1.44	76.86	21.53	-55.33
Spain	104.32	110.73	6.41	12.58	14.47	1.89

Source: We have considered all F&Vs for which price data were available from Government of Canada, USDA, and Eurostat.

4.1. Prices of F&Vs in Canada

As noted by Richards and Rickard (2020), Canadian wholesalers, distributors, and retailers have managed to keep relatively complete assortments of F&Vs at reasonable prices. However, despite a reduction in F&V price levels and volatility in both Montreal (-0.06 $ in average price and -0.27 $ in average deviation) and Toronto (-0.41 $ in average price and -0.99 $ in average deviation) (table 3), almost half of F&V prices in Canadian markets increased in level and in variability (fig. 1). In particular, prices tended to increase for F&Vs for which Canada is major importer, such as grapefruit and oranges. According to data from USDA FAS PS&D, Canada imports about 200,000 t of oranges and 37,000 t of fresh grapefruit per year.

Figure 1. Percentage of products reporting an increase in price levels and price deviations between periods March-June 2019 and March-June 2020 in Canadian markets.



A note of caution is necessary in that the Provinces of Ontario and Quebec are very large, and the cities of Toronto and Montreal are relatively near each other.

Source: Elaboration on data from Government of Canada.

Between March-June 2019 and March-June 2020, Montreal and Toronto exhibited similar median variations in price levels for products reporting a price increase (3.32 $ and 3.62 $, respectively) and for products reporting a price decrease (-3.38 $ and -4.36 $, respectively). Differently, the median variation in price volatility between the two periods was larger for products reporting a price increase and lower in products reporting a price decrease in Montreal than in Toronto; i.e. 3.72 $ *versus* 4.38 $ and -3.95 $ *versus* -4.93 $ (table 4). Put differently, the price increase and price decrease were similar in magnitude, but not in variability: when prices increased, they also were more erratic, an interesting phenomenon that is worthy of investigation.

Table 3. Median variations in average prices and average deviation in prices between March-June 2019 and March-June 2020 in Canadian markets.

	Median variation ($)			
	Average prices		*Average deviation in prices*	
Markets	Increase	Decrease	Increase	Decrease
Montreal	3.32	-3.38	3.72	-3.95
Toronto	3.62	-4.36	4.38	-4.93

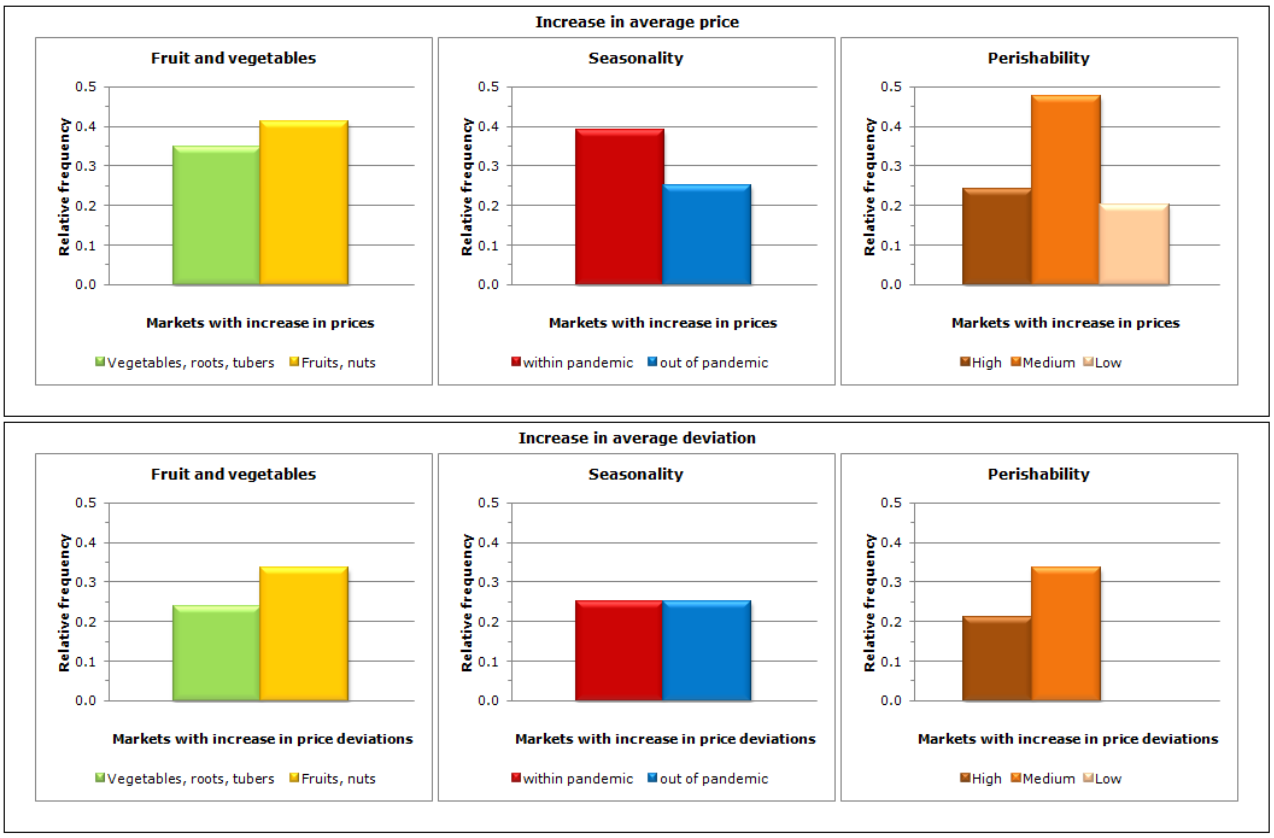
Source: Elaboration on data from Government of Canada.

Figure 2 shows that, both in Montreal and Toronto, an increase in the price level and price volatility occurred with greater frequency for fruit and nuts (41% in average price and 33% in average deviation in price) than for vegetables, roots and tubers (35% in average price and 24% in average deviation in price).

While price volatility seemed unaffected by seasonality, the price level rose the most for F&Vs whose market season occurred at the same time of the pandemic's onset (39% as compared to 25% of commodities marketed in seasons outside of the pandemic's onset). Some examples are kiwi fruit and lettuce, the former marketed during the winter and spring and the latter marketed during the spring (USDA, 2020). According to data from the Government of Canada, kiwi fruit and lettuce exhibited a median variation in price level of +18% and +4%, respectively, between March-June 2019 and March-June 2020.

The analysis also reveals that medium-perishable commodities were the most affected in terms of price surges and variability. In both Montreal and Toronto, 48% of medium-perishable commodities but only 24% of high-perishable commodities saw an increase in price. Similarly, an increase in the average deviation of prices occurred in 33% of medium-perishable commodities (fig. 2). Richards and Rickard (2020) observe that during the pandemic, Canadian consumers, worried about possible shortages in food stores, tended to stockpile non-perishable commodities. This phenomenon likely explains the increase in the price level of medium-perishable F&Vs. However, Richards and Rickard report examples of sporadic instances in Canada in which some of the more storable commodities, such as potatoes and sweet potatoes, were sold out. Accordingly, our data show increases in average prices of 6% for potatoes and 11% for sweet potatoes between March-June 2019 and March-June 2020. In addition, medium-perishable commodities supplied primarily through imports (e.g. oranges, grapefruit) saw price increases.

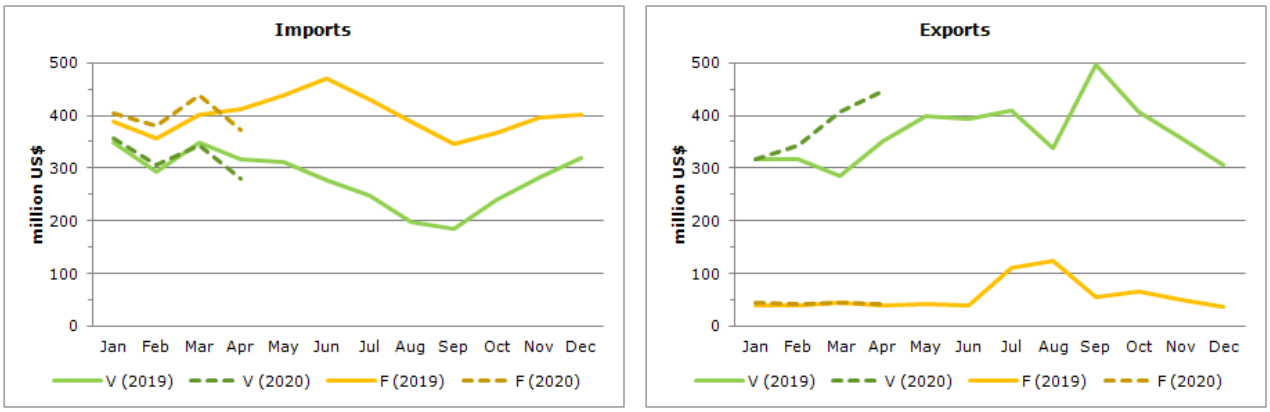
Figure 2. Increases in price and price deviations from March-June 2019 to March-June 2020 in Montreal and Toronto.



Source: Elaboration on data from Government of Canada.
Notes: Relative frequencies of products for which prices (or price deviations) increased in both markets. Shelf-life is up to 1 month for high-perishable F&Vs, 1-6 months for medium-perishable F&Vs, and greater than 6 months for low-perishable commodities.

According to StatsCan (2020) and Statista (2020), monthly sales of imported F&Vs were about seven times larger than sales of domestically produced F&Vs (about 125 million C$) in Canada in 2018. Given Canada's strong dependence on imported F&Vs, the country's importers, distributors, and retailers are likely to have been directly affected by the pandemic (Richards and Rickard, 2020). As the pandemic started to spread in Canada (April 2020, see fig. A.1 in Appendix A.1.1), the value of F&V imports started to decline. In particular, imports of fruit and nuts decreased by 19% (-67 million US$) in April 2020 with respect to the previous month, while imports of vegetables, roots, and tubers fell by 15% (-65 million US$). F&V exports performed differently: while exports of fruit and nuts between January and April 2020 followed the same patterns observed in the first months of 2019, exports of vegetables, roots, and tubers were 43% higher in March 2020 than in March 2019 (408 million versus 286 million US$).

Figure 3. Trends in F&V trade flows in Canada, 2019-20.



Source: Elaboration on data from UN Comtrade.
Note: V indicates vegetables, roots, tubers; F indicates fruit, nuts.

Most of Canada's F&V imports come from the US (Statista, 2020), and this exposes Canadian markets to shocks occurring in the US. Although the US-Canada border remained open to trade during the pandemic, restrictions on the cross-border movement of workers imposed in response to the spread of COVID-19 created several challenges for Canada's import-dependent firms. These firms faced two main challenges: a reduced availability of guest workers during the growing season[7] and the need to raise wages to attract domestic workers. Therefore, F&V prices suffered from changes in US costs of production (Richards and Rickard, 2020). These effects are likely to be observed in the long run.

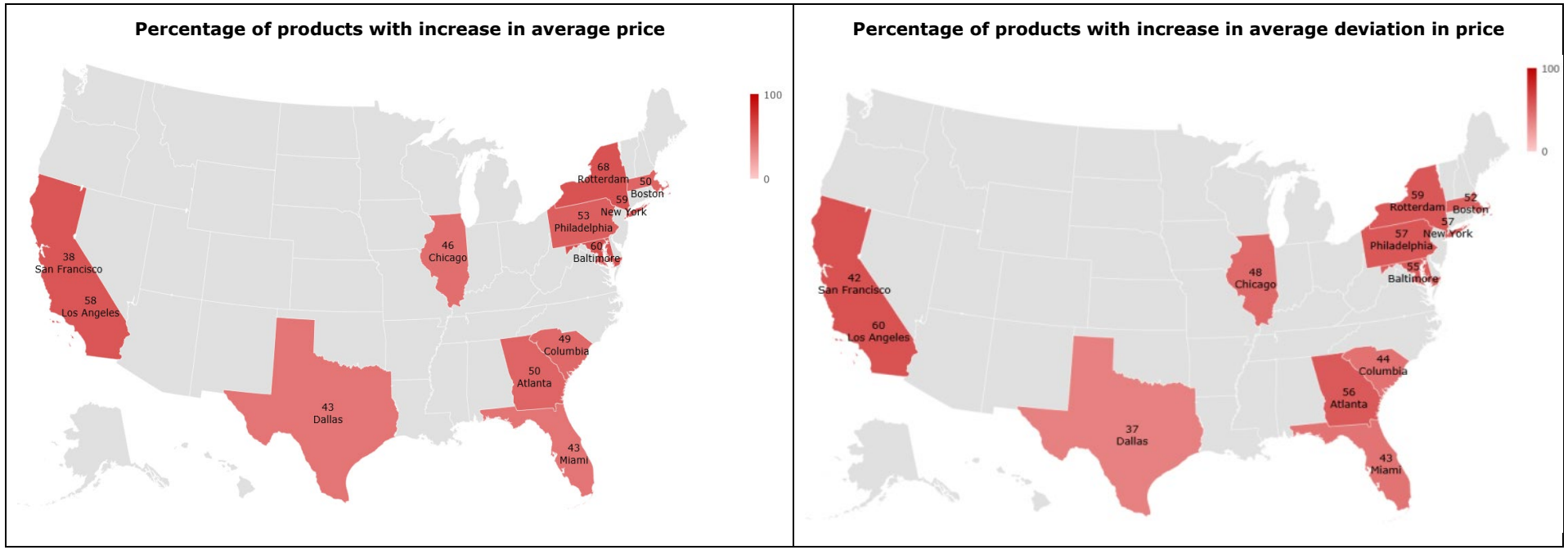
4.2. Prices of F&Vs in United States

The US tended to report surges in both the level and volatility of F&V prices in most markets (table 3). Accordingly, more than half of F&V commodities in US markets reported an increase in average price and average deviation in price (fig. 4). The most affected market was Rotterdam: with increases of 1.85 $ in average price and 2.97 $ in average deviation in price, 68% of F&V commodities in that market exhibited an increase in the price level, and 59% saw upward variability in prices (table 3, fig. 4).

A few markets (Atlanta, Miami, San Francisco) reported a reduction in the F&V price level (-1.68$) and price volatility (-2.26 $) (table 3). These three markets were also among the least affected in terms of the percentage of F&V commodities reporting an increase in price (38%) and in price deviation (42%) between March-June 2019 and March-June 2020 (fig. 4). Despite a reduction in the average F&V price level in Atlanta (-1.12 $) and Miami (-0.48 $) (table 3), half of the F&V commodities in Atlanta and 43% of the commodities in Miami reported an increase in average price (fig. 4). Prices tended to increase for F&Vs for which the US is the main supplier in North America; examples are apples, oranges, table grapes, and tangerines. According to USDA data, these commodities accounted for 4.95, 4.85, 1.58, and 1.12 million t of total distribution in 2020, respectively.

[7] Part of the guest workers admitted in Canada (about 60,000 per year) are employed in the F&V industry (Richards and Rickard, 2020).

Figure 4. Percentage of products reporting an increase in average price and average deviation in price between periods March-June 2019 and March-June 2020 in US markets.



Source: Elaboration on data from USDA.

Between March-June 2019 and March-June 2020, several US markets exhibited a growth in price level for F&V products. The changes for products reporting a price decrease were much lower. This is also reflected in the median variation in upward price deviations which increased to three figures in 7 out of 12 US markets as compared to the reduction in the median variation in downward price deviations (table 5). The highest values in upward price deviations were observed in the metropolitan areas of Philadelphia (+3.49 $), San Francisco (+3.44 $), and Baltimore (+3.22 $), which were among the most affected by the pandemic[8] in absolute terms (see Appendix A.1.2). It should be noted, however, that these cities are also among the most populous of the US.

Overall, F&V prices in the US seemed to be more affected by the pandemic in terms of price volatility than in price level. As noted in Mead et al. (2020), efforts to limit the spread of the pandemic (e.g. restrictions in movements, stay-at-home orders) contributed to fluctuations in domestic producer prices, particularly in the food sector. Producers faced difficulties in reorienting their processing and supply channels from restaurants and institutional customers, characterised by a contraction in demand, to supermarkets and grocery stores, which responded to the increased demand for products for use at home.

Table 4. Median variations in average prices and average deviation in prices between periods March-June 2019 and March-June 2020 in US markets.

	Median variation (%)			
	Average prices		*Average deviation in prices*	
Markets	Increase	Decrease	Increase	Decrease
Atlanta	2.17	-1.95	2.70	-3.14
Baltimore	3.06	-2.32	2.94	-3.22
Boston	2.21	-1.38	2.16	-2.82
Chicago	2.91	-1.94	3.09	-2.57
Columbia	3.53	-1.27	4.03	-1.85
Dallas	2.65	-1.81	2.73	-2.27
Los Angeles	4.11	-2.56	4.48	-2.64
Miami	2.24	-0.82	2.11	-2.13
New York	2.76	-2.64	3.43	-2.74
Philadelphia	2.16	-2.15	2.88	-3.49
Rotterdam	2.15	-0.86	1.65	-2.21
San Francisco	2.39	-2.09	2.15	-3.44

Source: Elaboration on data from USDA.

Figure 5 highlights common and localised behaviours in US markets. In 75%-100% of US markets, an increase in the price level and price volatility occurred with a higher frequency for fruit and nuts (31% in both average price and average deviation in price) than for vegetables, roots and tubers (25% in average price and 28% in average deviation in price). The opposite is true when we consider F&V commodities reporting an upward trend in price in a few US markets (up to 25% of markets). For instance, according to data from USDA, cherries exhibited an increase in the price level in 8 out of 12 US markets; cherry prices (median value) increased the most in Rotterdam (+82.28%), New York (+61.32%), and Philadelphia (+54.04%). Cherries also reported a large increase in the price deviation in Los Angeles (+2,535.94%). The US imports about half of its fruit and about 20% of its vegetables from Mexico during the spring and summer (Mead et al., 2020). The value of F&V imports reached a minimum in April 2020; however, this decline is more relevant for fruit and nuts than for vegetables, roots, and tubers with respect to trends observed in April 2019. Imports of fruit and nuts decreased by 16% (-311

[8] A note of caution is necessary in that data may be differ for cities and states. Data on per capita case levels were not available when the study has been conducted.

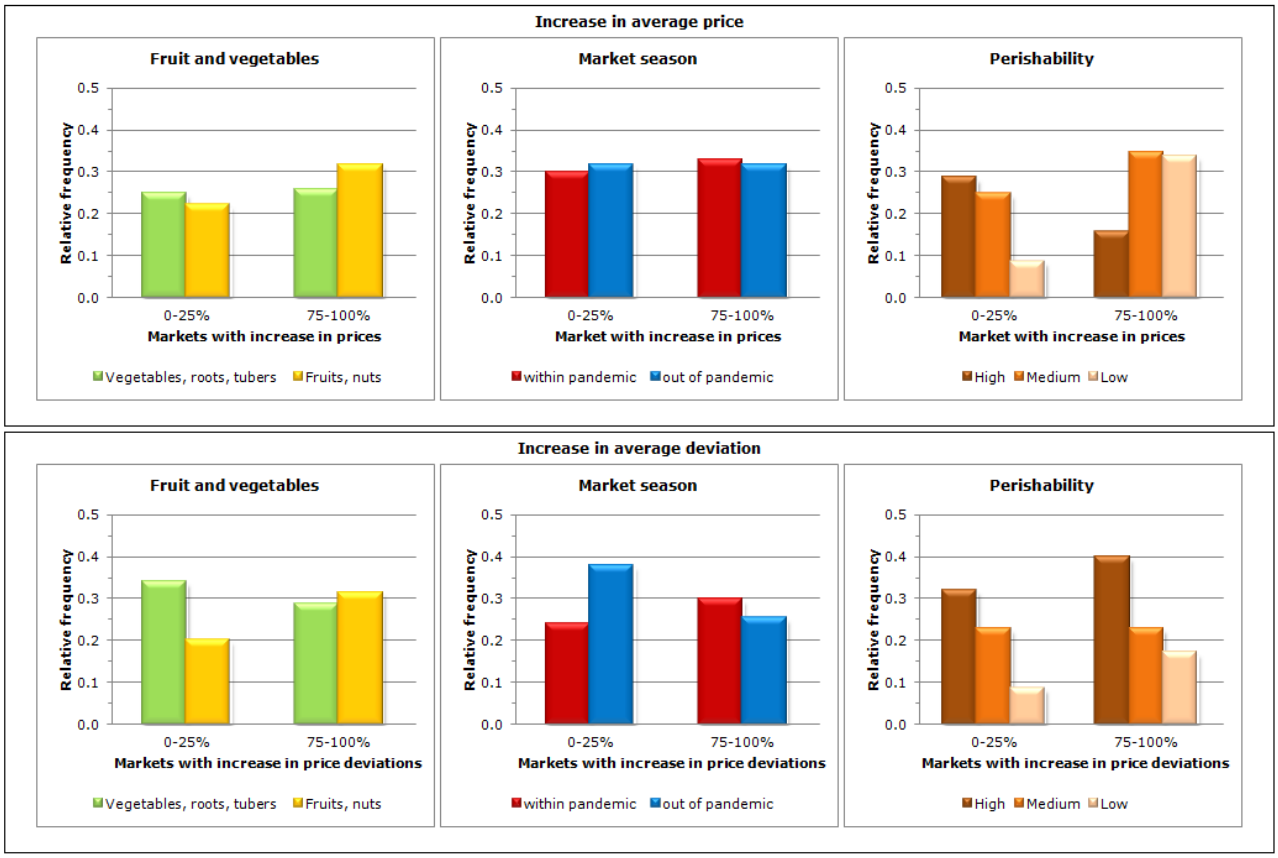
million US$), whereas imports of vegetables, roots, and tubers decreased by 4% (-38 million US$) in April 2020 compared with April 2019 (fig. 6). Although US borders remained open to trade during the crisis, pressures came from frictions on cross-border movements between the US and Mexico, with some consequences on F&V value chains. In fact, despite the fact that the U.S. Government allowed workers with permits to enter the United States during the pandemic, it is likely there has been a shortage of seasonal, irregular workers, with consequences on the harvest season of some F&Vs (Richards and Rickard, 2020; Schmidhuber et al., 2020).

While the price level did not seem to be affected by seasonality, price volatility tended to rise more for F&Vs whose market season occurred outside the initial pandemic period, an outcome that was different from our expectations. Overall, F&V commodities reported an upward trend in average prices in 30% of cases, regardless of the market season: this was both a common and a localised behaviour (fig. 5). Emblematic examples were bananas and grapes, imported and marketed throughout the year (USDA, 2020). Our data show that, although with a modest median value (+3.68%), an upward variation in the price level between the periods March-June 2019 and March-June 2020 occurred in 10 out of 12 US markets; upward variation in price variability, more marked in the median value (+68.60%), was observed only in 7 US markets. Downward but moderate variations in the price level were observed for grapes in all US markets (-5.79%, median value), and a decrease in price deviations of grapes occurred in all but two US markets: Philadelphia (+44.11%) and San Francisco (+13.88%).

The analysis highlights a common behaviour observed in more than 75% of the US markets studied: low-perishable commodities were the most affected by price surges but did not see noteworthy changes in price variability (fig. 5). During the crisis, consumption was driven in part by panic-buying behaviour of consumers (Richards and Rickard, 2020). In contrast, in more than 75% of the US markets studied, the prices of high-perishable F&Vs were quite volatile (fig. 5).

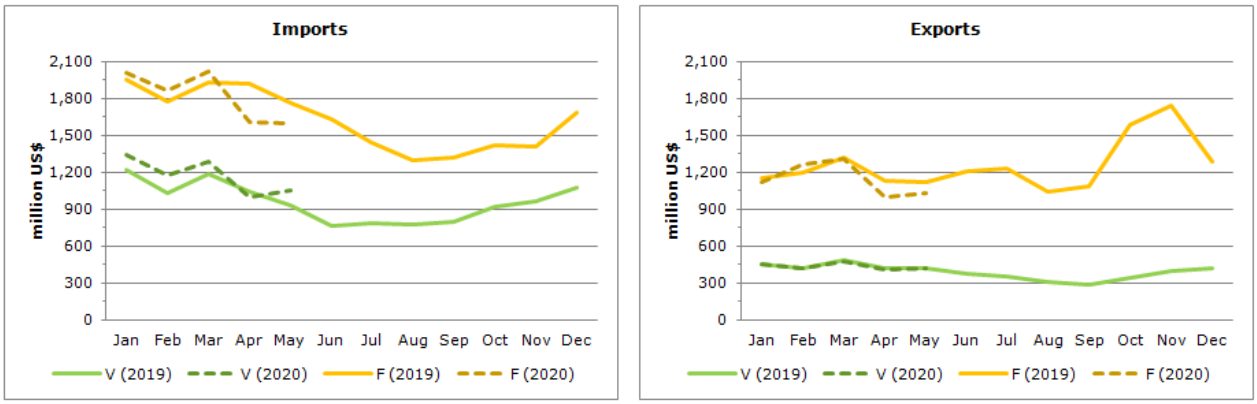
The value of F&V exports exhibited trends similar to those observed in 2019; slight differences were observed since March 2020 for fruit and nut exports (fig. 6). Mead et al. (2020) provide evidence that the price of nut exports decreased by 20.5% from December 2019 to June 2020 due to a loss in demand from Asia, associated with restaurant closures and decreased purchases of those nuts perceived as luxury foods. Accordingly, our data show a drop in nut prices in California markets. For instance, Los Angeles showed price reductions of 41.89% for filberts, 33.61% for pecans, 30.16% for chestnuts, 27.05% for Brazil nuts, and 14.53% for almonds. As was well synthesised by Cox in an article published in *The Record* (July 2020), "almond growers fret over expectations for another record harvest."

Figure 5. Percentage of US markets reporting an increase in average price and average deviation in price between periods March-June 2019 and March-June 2020.



Source: Elaboration on data from USDA.
Notes: Shelf-life is up to 1 month for high-perishable F&Vs, 1-6 months for medium-perishable F&Vs, greater than 6 months for low-perishable commodities.

Figure 6. Trends in F&Vs trade flows in the United States, 2019-20.



Source: Elaboration on data from UN Comtrade.
Note: V = vegetables, roots, tubers; F = fruit, nuts.

4.3. Prices of F&Vs in Mexico

F&V prices seemed particularly sensitive in Mexico, which experienced a marked surge in price level and price volatility in all three markets studied, with Mexico City being the most affected of the three. Mexico City reported an increase of 9.62 $ in the average price level from March-June 2019 to March-June 2020 and price variability rising from 0.86% to 31.43% across the same two periods (table 3). The increase in price level and price volatility was common to all F&V commodities in the Mexican markets studied. The average price increased for more than 90% of F&V commodities, and average deviations in price affected all the F&V commodities studied in Monterrey and Mexico City (fig. 7).

Guadalajara and Mexico City exhibited similar median variations in the price level for products reporting a price increase (4.29 $ and 4.94 $, respectively), while the median variation was much lower in Monterrey (2.43 $). The average variation in prices in Mexican markets was impressive. The median variation in price volatility for products reporting a price increase was about two-times larger in Guadalajara (12.46 $) and Mexico City (15.75 $) than in Monterrey (7.52 $) (table 6).

Table 5. Median variations in average prices and average deviation in prices between periods March-June 2019 and March-June 2020 in Mexican markets.

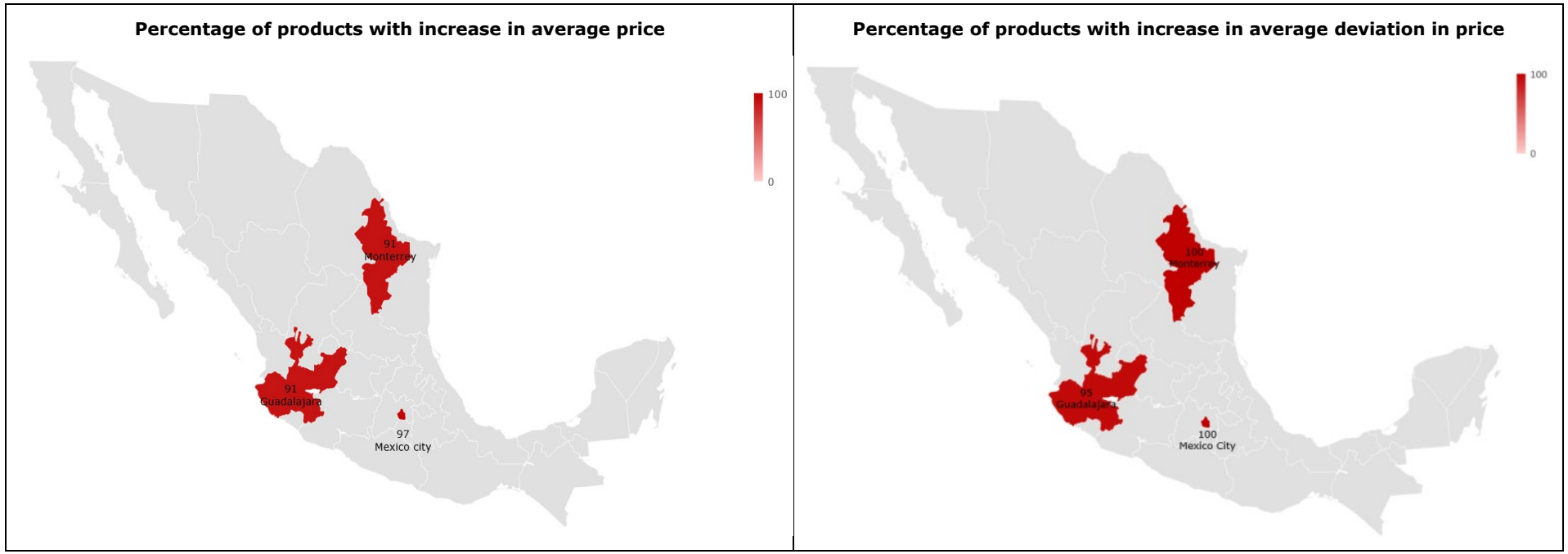
	Median variation ($)			
	Average prices		*Average deviation in prices*	
Markets	Increase	Decrease	Increase	Decrease
Guadalajara	4.29	-8.06	12.46	-14.36
Mexico City	4.94	-2.13	15.75	-
Monterrey	2.43	-0.65	7.52	-

Source: Elaboration on data from USDA.

Figure 8 confirms a dramatic situation in the Mexican markets studied: common tendencies were observed in Guadalajara, Mexico City, and Monterrey. Fruit and nuts were the most affected commodities, with increases in the price level occurring in 95% of cases and increases in price variability occurring in all the cases. According to USDA data, oranges were the fruit most hit by price surges (+185.54% in Guadalajara, +185.42% in Mexico City, +92.88% in Monterrey), whereas plums and pineapples showed alarming median variations in price deviations across markets (+6,416.71% for plums and + 5,746.93% for pineapples). The price changes for vegetables, roots, and tubers were also impressive, with increases in the price level and in price variability in 75% and 92% of cases, respectively. Noteworthy increases in prices were reported for cucumbers, which showed a median variation of +261.59% across markets; beets, lettuce, and parsley were the most affected F&V commodities in terms of variations in price deviations between the periods March-June 2019 and March-June 2020 (+9,486.59% for beets, +6,804.51% for lettuce, +6,131.04% for parsley; median values across markets).

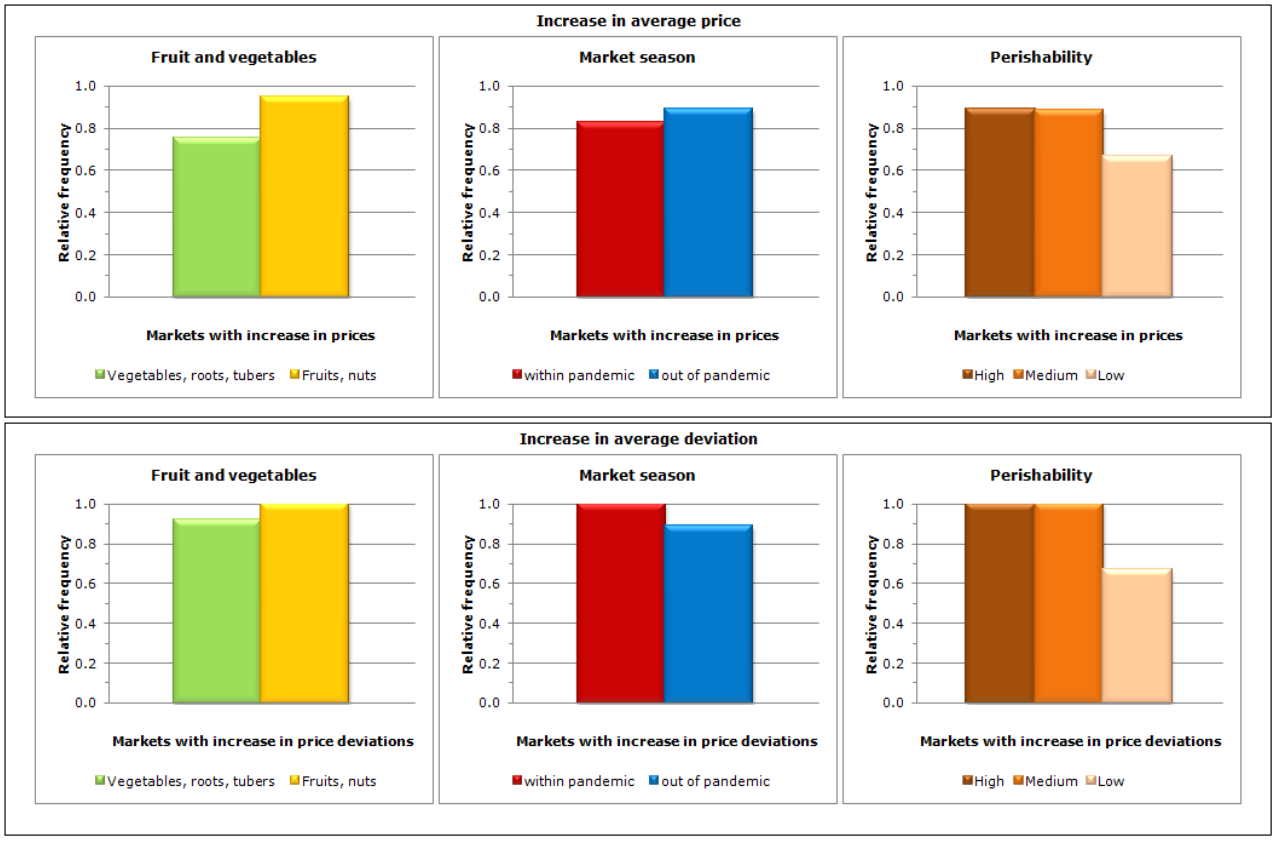
In all Mexican markets, price volatility rose for all F&V commodities whose marketing season occurred at the same time as the onset of the pandemic. Apples, marketed during the winter and spring (USDA, 2020), are one key example. According to USDA, apples exhibited a median variation in the price level and price volatility of +34% and +2,058.23%, respectively, between the periods March-June 2019 and March-June 2020.

Figure 7. Percentage of products reporting an increase in average price and average deviation in price between periods March-June 2019 and March-June 2020 in Mexican markets.



Source: Elaboration on data from USDA.

Figure 8. Increase in average price and average deviation in price between periods March-June 2019 and March-June 2020 in all Mexican markets.



Source: Elaboration on data from USDA.
Notes: Relative frequencies refer to cases in which all the Mexican markets studied (i.e., Guadalajara, Mexico City, and Monterrey) reported an increase in average price and in average deviation in price between periods March-June 2019 and March-June 2020. Shelf-life is up to 1 month for high-perishable F&Vs, between 1 and 6 months for medium-perishable F&Vs, and greater than 6 months for low-perishable commodities.

In Guadalajara, Mexico City and Monterrey, an increase in the price level and volatility occurred with a higher frequency for high- and medium-perishable F&V commodities than for low-perishable F&V commodities. An increase in the average deviation of prices occurred in 100% of cases for both high-perishable and medium-perishable commodities (fig. 8). Noteworthy examples are beets, pineapples, and mushrooms: according to USDA data, they were the high-perishable F&V commodities most affected by price variability between the periods March-June 2019 and March-June 2020.

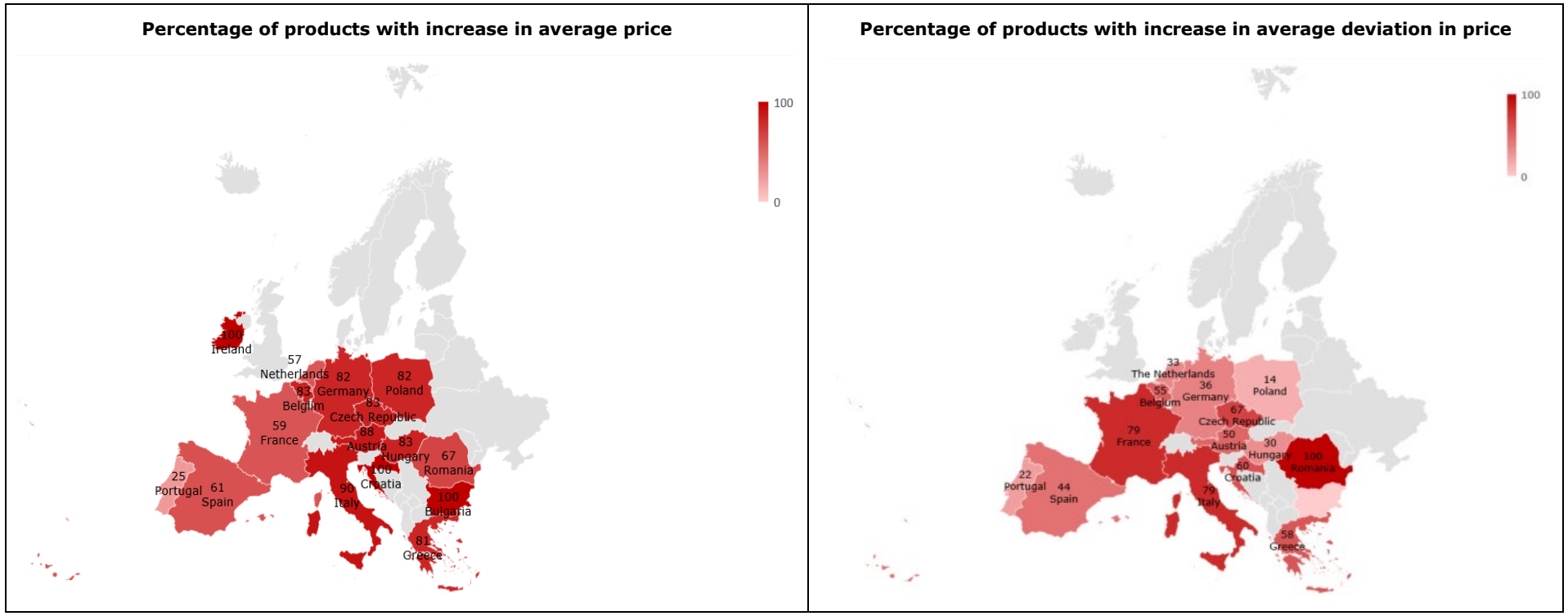
4.4. Prices of F&Vs in European Union

In the EU, while price levels of F&V commodities experienced a generalised increase (from +4.84 $ in Croatia to +36.92 $ in France), deviations in prices tended to decrease, except in Portugal (+12.95 $), France (+11.02 $), and the Netherlands (+27.87 $) (table 3). However, at the product level, we observe that most F&V commodities were characterised either by a high price level and low price variability or by a low price level and high price variability during the period March-May 2020 as compared to the same period in 2019. For instance, in Austria, 88% of F&V commodities reported an increase in average price and in price variability, but only half showed a growing average deviation in price. Similarly, in Germany and Poland, where 82% of F&V commodities showed increases in average prices, a lower percentage of products had upward

price variability (36% and 14%, respectively). The same conclusions are valid for Bulgaria and Croatia, where prices of all F&Vs saw an increase in level but not in variability. An opposite situation occurred in Romania: against an increase in average deviation in prices of all F&Vs, Romania reported increases in average prices only for two-thirds of F&V commodities. Exceptions to this general tendency included Italy and France, where the percentage of products reporting an increase in the price level and price variability was similar; i.e., 90% in average price *versus* 79% in average deviation in price in Italy, and 59% in average price *versus* 79% in average deviation in price in France (fig. 9). Prices tended to increase in all EU countries for fruit of which the EU is a great producer. According to USDA/FAS data, in 2020, the EU produced more than 11 million t of apples, 6 million t of oranges, 3 million t of peaches and nectarines, 2 million t of pears, one million t of table grapes, and one million t of lemons.

Food sales in the EU increased in March 2020, partly due to anxiety of some consumers, and then declined in the following months (April-May 2020), returned to normal levels after the expansion experienced during the lockdown phase, and then started to grow again in June 2020 (Eurostat, 2020).

Figure 9. Percentage of products reporting an increase in average price and average deviation in price between periods March-May 2019 and March-May 2020 in EU markets.



Source: Elaboration on data from Eurostat.

Between the periods March-June 2019 and March-June 2020, France, Poland, and Romania exhibited the highest median variations in the price level for those products reporting a price increase (+58.15 $, 32.49 $, and 36.64 $, respectively). In contrast, the median variation in price volatility was higher in Poland for products reporting a price increase (+50.30 $) and higher in Italy for products reporting a price decrease (-56.31 $) (table 7).

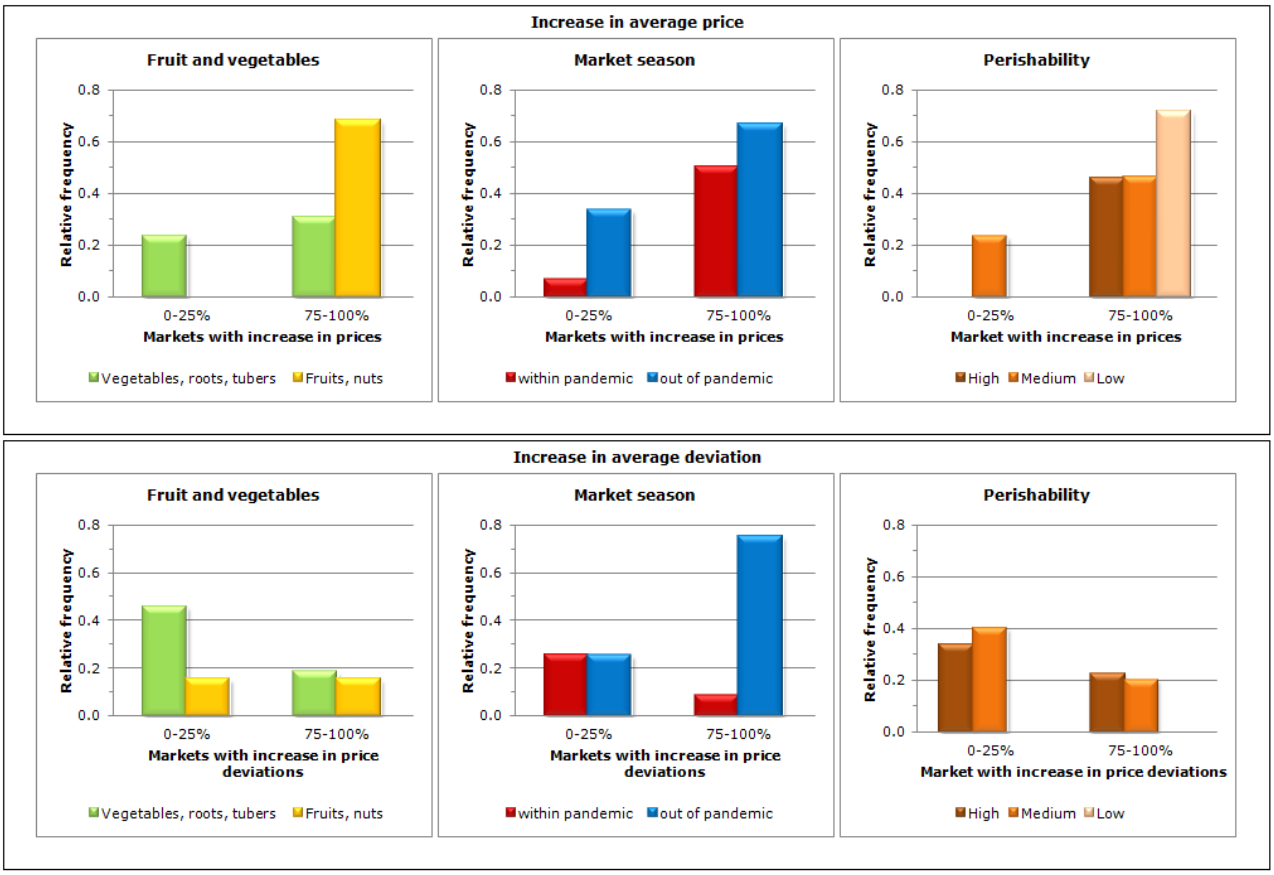
Table 6. Median variations in average prices and average deviation in prices between periods March-May 2019 and March-May 2020 in EU markets.

	Median variation ($)			
	Average prices		*Average deviation in prices*	
Markets	Increase	Decrease	Increase	Decrease
Austria	25.83	-	5.78	-8.24
Belgium	18.18	-44.89	12.81	-22.85
Bulgaria	19.09	-	-	-37.38
Croatia	20.57	-	15.93	-23.12
Czech Republic	18.95	-3.77	3.12	-3.13
France	58.15	-2.66	27.08	-22.28
Germany	19.61	-32.78	9.87	-5.99
Greece	23.07	-5.31	3.47	-15.67
Hungary	11.21	-40.02	18.48	-15.52
Ireland	8.81	-	-	-
Italy	17.12	-6.25	8.17	-56.31
The Netherland	20.25	-18.46	31.27	-14.70
Poland	32.49	-8.68	50.30	-10.99
Portugal	7.03	-8.25	3.95	-4.55
Romania	36.64	18.18	15.33	-
Spain	20.58	-4.88	7.06	-8.98

Source: Elaboration on data from Eurostat.

Figure 10 shows common and localised behaviours in EU markets, the former typical of 75%-100% of EU markets and the latter characterising up to 20% of EU markets. A marked increase in the price level was more common for fruit and nuts than for vegetables, roots, and tubers across EU markets. In fact, for 68% of fruit and nuts, the price increases were generalized (i.e. in almost all markets), while this was true only for 31% of vegetables, roots, and tubers. No relevant differences were observed for F&V commodities reporting an upward trend in the price deviation between the periods March-June 2019 and March-June 2020. Generalised increases in prices of fruit and nuts in EU markets may be associated with shocks in demand and shortages of labour. Demand shocks disrupted markets for perishable goods such as F&Vs at the country level. In addition, France, Portugal, and Greece faced some problems in meeting the labour demand of the F&V sector, despite the fact that the EU established a green corridor allowing for the mobility of guestworkers across EU borders (MED-Amin, 2020). Growers, who could no longer rely on a ready supply of guestworkers, were unable to schedule the coming harvest season for most F&Vs (Schmidhuber et al., 2020).

Figure 10. Percentage of EU markets reporting an increase in average price and average deviation in price between periods between periods March-May 2019 and March-May 2020.



Source: Elaboration on data from Eurostat.
Notes: Shelf-life is up to 1 month for high-perishable F&Vs, 1-6 months for medium-perishable F&Vs, and greater than 6 months for low-perishable commodities.

Both the price level and price volatility of F&Vs tended to rise more for commodities whose market season occurs outside of the initial pandemic period, an outcome that differed from our expectations. Such price behaviour occurred in most EU markets (fig. 10). Examples include cauliflowers and pears, the former marketed during the winter and the latter marketed during autumn and winter (USDA, 2020). According to data from Eurostat, cauliflowers and pears exhibited, between the periods March-June 2019 and March-June 2020, a median variation in the price level of +75.75% and +74.60%, respectively, and in price variability of +51.36% and +154.15%, respectively.

The analysis also reveals that, a common behaviour in 75%-100% of EU markets, low-perishable commodities were the most affected by price surges but did not show changes in price variability (fig. 10). EU countries experienced hoarding during the initial months of the pandemic, and consumers tended to stockpile non-perishable commodities, with consequent pressures on the price level of low-perishable F&Vs. Our evidence is consistent with the findings of Akter (2020) that the severity of stay-at-home restrictions in the EU increased food prices by 1% in March and April 2020, with the most significant surges in prices observed for meat, fish and seafood, and vegetables.

5. Normative analysis

Few words of caution are needed: linking prices and policy responses is challenging and beyond the scope of the present paper. We describe some elements that may help the debate and leave the analysis of how policy measures and price dynamics are related for future work.

Policymakers in different regions of the world have imposed severe restrictions to mitigate the spread of the pandemic and to limit the pandemic's economic effects. Schools and businesses were shuttered, gatherings banned, and in several countries, stay-at-home orders entered into force. Table 8 provides an overview of lockdown measures imposed by governments of selected countries in the first semester of 2020 to contain the spread of COVID-19. Limiting interactions stems person-to-person contagion, but at a high cost to economic activity. For instance, Goodman-Bacon and Marcus (2020) report that business closures in the EU reduced GDP by an estimated 3% per month.

Table 7. Lockdown measures imposed by governments in the first semester of 2020 to contain the pandemic.

Country	Starting date	Source
Canada	Mar 18, 2020[9]	The Manitoulin Expositor
United States		Aura Vision
Oregon	Mar 24, 2020	
Rhode Island	Mar 30, 2020	
Georgia	Apr 03, 2020	
Indiana	Mar 24, 2020	
Kansas	Mar 30, 2020	
Tennessee	Apr 02, 2020	
Ohio	Mar 23, 2020	
Missouri	Apr 03, 2020	
Maine	Apr 02, 2020	
Kentucky	Mar 23, 2020	
Iowa	Mar 25, 2020	
Idaho	Mar 25, 2020	
Vermont	Mar 25, 2020	
North Dakota	Mar 30, 2020	
Montana	Mar 28, 2020	
Mississippi	Apr 03, 2020	
Florida	Apr 03, 2020	
Arkansas	Mar 19, 2020	
Alaska	Mar 28, 2020	
Arizona	Mar 31, 2020	
Alabama	Mar 18, 2020	
New Hampshire	Mar 27, 2020	
West Virginia	Mar 24, 2020	
Texas	Apr 02, 2020	
Utah	Mar 26, 2020	
Colorado	Mar 26, 2020	
North Carolina	Mar 30, 2020	
South Carolina	Apr 07, 2020	
Pennsylvania	Apr 01, 2020	
Louisiana	Mar 23, 2020	
Nevada	Mar 17, 2020	
New Mexico	Mar 24, 2020	
Delaware	Mar 24, 2020	
Minnesota	Mar 27, 2020	
Massachusetts	Mar 24, 2020	

[9] More details available at: https://pm.gc.ca/en/news/news-releases/2020/03/16/prime-minister-announces-new-actions-under-canadas-covid-19-response

Connecticut	Mar 23, 2020	
Illinois	Mar 21, 2020	
Hawaii	Mar 25, 2020	
Michigan	Mar 24, 2020	
New York	Mar 22, 2020	
California	Mar 19, 2020	
Virginia	Mar 24, 2020	
Oklahoma	Apr 01, 2020	
Oregon	Mar 23, 2020	
Washington	Mar 25, 2020	
Wisconsin	Mar 25, 2020	
Maryland	Mar 30, 2020	
New Jersey	Mar 21, 2020	
Mexico	Mar 21, 2020	Aura Vision
European Union		
Austria	Mar 16, 2020	ORF
Belgium	Mar 18, 2020	The Guardian
Bulgaria	Mar 13, 2020	Aura Vision
Croatia	Mar 18, 2020	Total Croatia News
Czech Republic	Mar 16, 2020	Aura Vision
France	Mar 17, 2020	The Independent
Germany	Mar 23, 2020	Spiegel
Greece	Mar 23, 2020	Reuters
Hungary	Mar 28, 2020	Reuters
Ireland	Mar 12, 2020	Irish Times
Italy	Mar 9, 2020	The Wall Street Journal
The Netherlands	Mar 16, 2020	Aura Vision
Poland	Mar 13, 2020	The First News
Portugal	Mar 19, 2020	The Portugal News
Romania	Mar 25, 2020	DIGI 24
Spain	Mar 14, 2020	El Mundo

In order to understand how policy interventions and measures implemented to limit the contagion or to react to the economic crisis influenced price dynamics for F&Vs, we compare the variation in the average F&V price level and price deviation between the periods March-June 2019 and March-June 2020[10] (fig. 11) and the policy measures and urgent actions implemented to limit the effects of the pandemic in the agri-food sector (fig. 12).[11]. Figures 11 and 12 highlight a correlation between the policies implemented and the evolution of the price level. Where public interventions were not many (such as in the US) or very few (Mexico), F&V prices tended to increase both in level and variability. In contrast, in the EU countries, where the number of policy interventions was high, increases in the level and volatility of F&V prices tended to be more limited, with a few exceptions (for instance, Poland, which reported an increase in the price level but not in price deviations).

During the pandemic, some actions were implemented in North America to limit the effects of COVID-19 (see table A.2), and regulatory actions were also taken by the government outside of the legislation. Mexico provided very few types of intervention, and a few measures were adopted in Canada and the US. Among the (few) actions taken by the Mexican Government was the suspension of regulatory activities for a certain period, allowing imports to proceed on existing permits while focusing their attention on products directly related to the pandemic.[12]

[10] Average price level and volatility of F&Vs are computed as average values across products and markets.
[11] A list of policy measures and urgent actions implemented to limit effects of the pandemic in Canada, the US, Mexico, and selected EU countries is available in table A.2 of Appendix A.3.
12 https://www.olivares.mx/covid-19-mexican-sanitary-regulatory-agency-cofepris-update/

Canada implemented a single intervention intended to improve access to credit and provide financial support through public banks. The intervention entered into force on March 23, 2020 and increased the capital base of Farm Credit Canada (FCC) by 5 billion C$. The minister of Agriculture and Agri-Food Canada, Marie-Claude Bibeau, announced a solid commitment of the government to ensure that agri-food producers, agribusinesses, and food processors had access to necessary capital during the crisis. More precisely, from March to Jun 2020, several measures were implemented in Canada:

- April 13, 2020 - The Government of Canada announced $50 million to help the sector to put in place measures to follow the mandatory 14-day isolation period required for temporary foreign workers. The Government of Quebec announced $45 million to attract Quebec workers to the fields, which included a $100 bonus for seasonal agricultural workers who worked a minimum of 25 hours per week.[13]
- May 14, 2020 – Farm Credit Canada launched a $100-million Agriculture and Food Business Solutions Fund to support proven, viable companies through unexpected business disruptions, such as the COVID-19 pandemic.[14]
- May 15, 2020 – The Government of Canada adopted some amendments to the Canadian Dairy Commission (CDC) Act to increase the CDC's borrowing limit from $300 million to $500 million. This was to allow cheese and butter to be stored temporarily and avoid waste.[15]
- May 26, 2020 – The Government of Canada announced an investment of up to $9.2 million to enhance the Youth Employment and Skills Program (YESP) and fund up to 700 new positions for youth in the agriculture industry.[16]
- Producers with loans under the Advance Payments Program having a reimbursement deadline in March or April 2020 and whose marketing options were reduced for their commodities were granted an additional six months to reimburse their outstanding loan balance.
- June 12, 2020 – The Government of Canada announced $77.5 million to help companies to implement changes to safeguard the health and safety of workers due to the impacts of the COVID-19 pandemic and to invest to improve, automate, and modernize facilities needed to increase Canada's food supply capacity.[17]
- June 17, 2020 – The Government of Canada announced the Beef Cattle Set-aside Program and the Hog Sector Support Program. These programs are intended tol help cover the increased costs of feeding market ready cattle and hogs due to COVID-19 related processing delays, while redirecting surplus pork products to help those in need.[18]

Through its Coronavirus Food Assistance Program (CFAP), the government provided 16 billion US$ in direct payments to agricultural producers to assist farmers in response to the pandemic.

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[13] https://www.canada.ca/en/agriculture-agri-food/news/2020/04/keeping- canadians-and-workers-in-the-food-supply-chain-safe.html

[14] https://www.canada.ca/en/agriculture-agri-food/news/2020/05/farm-credit-canada-backed-fund-offers-innovative-and-flexible-solutions-for-uncertain-times.html

[15] https://www.canada.ca/en/agriculture-agri-food/news/2020/05/helping-the-dairy-sector-mitigate-the-impact-of-covid-19.html

16 https://www.canada.ca/en/agriculture-agri-food/news/2020/05/government-of-canada-enhances-youth-employment-and-skills-program-to-help-create-new-positions-for-youth-in-the-agriculture-sector.html

17 1) https://www.canada.ca/en/agriculture-agri-food/news/2020/06/maintaining-and-strengthening-canadas-food-production-and-processing-sector.html; 2) https://www.agr.gc.ca/eng/agricultural-programs-and-services/emergency-processing-fund/?id=1591291974693

18 https://www.canada.ca/en/agriculture-agri-food/news/2020/06/canada-and-ontario-support-beef-and-hog-farmers-during-covid-19.html

Additionally, USDA provided $3 billion to purchase agricultural products for distribution to food banks and other non-profit organizations. A second Coronavirus Food Assistance Program, CFAP2, provided an additional $14 billion in assistance to agricultural producers.[19]

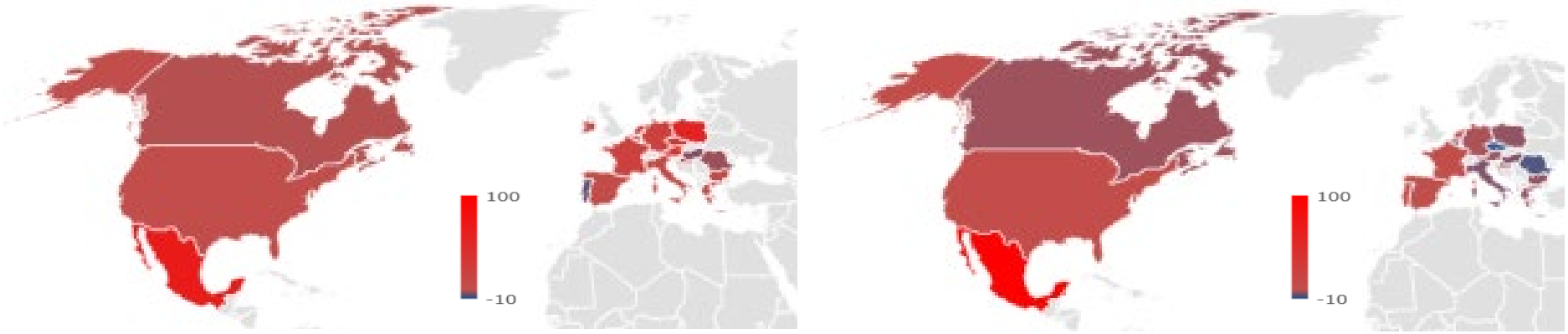
The US also took many other actions to assist the agri-food sector with the challenges presented by the pandemic:

- Adoption of the Pandemic Electronic Benefit Transfers for families with school-aged children,
- Increased Supplemental Nutrition Assistance Program (SNAP) benefits,
- Increased State participation in NAP online,
- Provided additional funding for other assistance programs, such as the Commodity Assistance Program and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and Children Nutrition Program,
- Increased the loan length of marketing assistance loans for crop commodities from 9 months to 12 months,
- Changed requirements for H-2A visas (temporary farm labor from abroad),
- Provided eviction and foreclosure relief for rural housing (through USDA Rural Development), and
- Provided assistance from USDA's Natural Resource Conservation Service (NRCS) and Animal and Plant Health and Inspection Service (APHIS) for the proper disposal of depopulated swine.

The timing of the interventions in Canada and the US is relevant to understand dynamics in F&V prices (figs. 11, 12). A contained variation in average deviations in Canadian F&V prices (periods March-June 2019 and March-June 2020) may be due to prompt intervention (end of March 2020), in contrast to the US which adopted some measures in May 2020.

[19] More details available at: https://crsreports.congress.gov/product/pdf/R/R46645

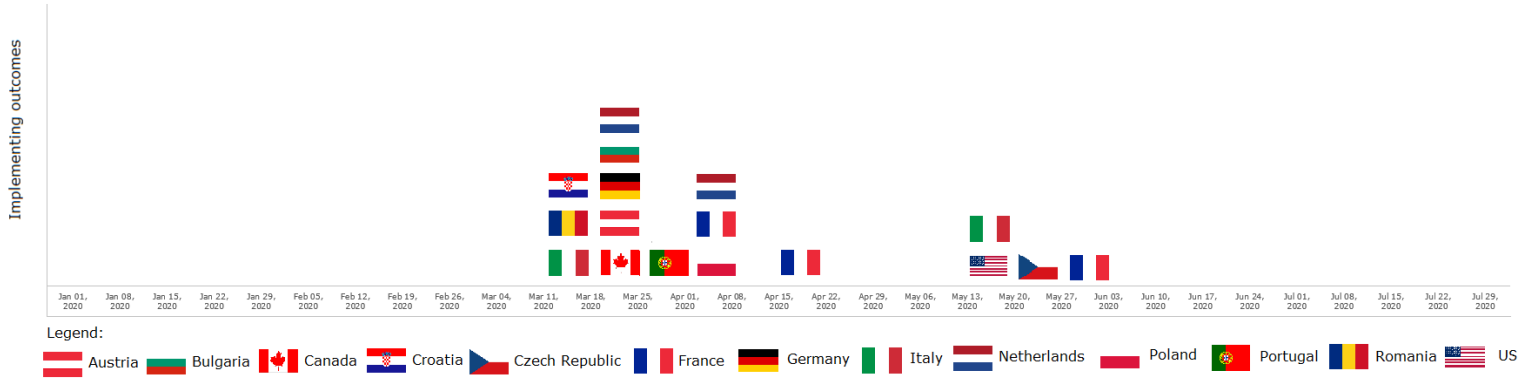
Figure 11. Average F&Vs price levels (a) and price deviations (b) in selected countries, between March-June 2019 and March-June 2020.



(a) (b)

Source: Elaboration on data from Government of Canada, USDA, Eurostat.

Figure 12. Policy measures and urgent actions implemented in selected countries to limit effects of the pandemic in the agri-food sector.



Source: Elaboration on data from FAPDA.
Notes: The figure reports only countries implementing measures related to the agri-food sector.

The actions implemented to limit the contagion or to react to the economic crisis have been numerous in EU countries. Governments in EU countries escalated interventions rapidly (see table A.2), with several interventions implemented on a single day in some cases, such as in Germany, France, and Italy (Flaxman et al., 2020).

The number of policy interventions was impressive in Italy, France, and Spain. However, Spain did not provide any action specifically for the agri-food sector, in contrast to Italy and France. In particular, to deal with direct and indirect damages arising from the COVID-19 emergency and to ensure the continuity of agricultural, fishing, and aquacultural businesses, the Italian 'Cura Italia' Decree N. 18 (March 16, 2020) set up a 100 million euro (111,087,000 US$) fund to support agriculture and fishing in 2020. This fund covered several agri-food products, and Italian processed F&V preparations (e.g. soup, minestrone, preserves) received 8 million euro. The aim was to encourage operators to purchase products from the Italian regions most affected by the COVID-19 emergency. A similar action was undertaken by Portugal, in which the Minister of Agriculture, Maria do Céu Albuquerque, launched a campaign called 'Alimente quem o Alimenta' to encourage the consumption of local products and the use of local markets. Similarly, the Romanian government developed online platforms to support small farmers and local producers and on March 13, 2020, launched the 'Tomata' support scheme in which subsidies were provided to Romanian tomato producers.

On March 16, 2020, the Italian government introduced a one-off bonus of 600 euro (666 US$) to self-employed and professional workers, including agricultural workers; on May 19, 2020, the "Relaunch Decree" increased the bonus to 1,000 euro (1,085 US$) for those self-employed and professional workers who could demonstrate a 33% reduction in income during March-April 2020 with respect to the same period in 2019.

In order to help businesses to cope with the consequences of the COVID-19 crisis, the French government postponed all deadlines for filing forms and similar declarations for the agricultural and farm income tax for the months of May and June (announced on April 17, 2020) and postponed upon request the payment of social security contributions (announced on June 2, 2020). In addition, on April 8, 2020, the French government banned imports of fresh cherries from countries where the use of the chemical dimethoate is permitted in cherry production.

Against these interventions in Italy and France, average price deviations of F&Vs seemed limited with respect to the price level (fig. 11).

Throughout the EU, several measures were implemented to support agri-food employment and to facilitate meeting labour demand. The revised 2020 budget in Bulgaria, approved on March 20, 2020, allowed the possibility for the registered unemployed to sign labour contracts with agricultural producers without losing their unemployment benefits. On March 21, 2020, Austria provided for the creation of an online platform to bring together sectors in need of workers and persons seeking work. The German government approved a measure on March 23, 2020, to connect farms and workers via an online platform, introduced more flexible rules that allowed the short-term unemployed and retired farmers to earn additional income without losing their social benefits, and allowed for the possibility to hire flexible workers across sectors. In the Netherlands, the government announced on April 7, 2020, the expansion of its COVID-19 compensation scheme, a fixed payment of 4,000 euro for three months to accommodate smaller farms and firms in the food industry. In contrast to Bulgaria, Austria, Germany, and the Netherlands, other EU countries such as France, Portugal, and Greece faced some problems in meeting labour demand in the F&V sector (MED-Amin, 2020). Producers, who could no longer

rely on a ready supply of guest workers, faced challenges in scheduling the harvest season for most F&Vs (Schmidhuber et al., 2020).

Other intervention measures favouring the agri-food sector included: the financial aid package of HRK 350 million prepared by the Croatian agricultural ministry (March 17, 2020); 38 billion euro allocated by the Austrian government to support farms (March 21, 2020); financial help of 4 million euro from the Netherlands Ministry of Agriculture through the Dutch 'calamity fund' (March 24, 2020); loans up to a total of 8 million PLN ensured by the Polish government to support the purchase of agricultural land, construction and modernisation of buildings used for agricultural production, creation of farm infrastructure, and purchase of agricultural machinery and equipment (April 3, 2020); and 3.3 billion CZK released by the Czech government for the 2020 Rural Development Program to support entrepreneurs in agriculture, food and forestry (May 26, 2020).

6. Comparative analysis

In order to assess the resilience of different and spatially separated markets of more/less perishable and of seasonal produce such as F&Vs in response to the pandemic (i.e., price stability), we obtain absolute differences in F&V prices between pairs of markets for the periods March-June 2019 and March-June 2020. The analysis of increases in absolute differences in F&V prices, obtained by comparing absolute differences between pairs of markets in March-June 2019 and March-June 2020, allows us to reflect on the efficiency of intra-regional and inter-regional food access and food availability, and on the functioning of markets in Canada, the US, Mexico, and selected EU countries.

In Canada, the markets of Montreal and Toronto exhibited a median variation in absolute differences in the price level of 75.14% for products reporting an increase in price differences and of -58.01% for products reporting a decrease in price differences, between the periods March-June 2019 and March-June 2020. In addition, 59% of F&V commodities reported an increase in absolute differences in prices between March-June 2019 and March-June 2020 (table 9).

Table 8. Percentage of products reporting an increase in absolute differences in prices between Canadian markets.

CAN	Montreal	Toronto
Montreal		
Toronto	59%	

Source: Elaboration on data from Government of Canada.
Notes: Absolute differences in prices between Canadian markets computed for periods March-June 2019 and March-June 2020. Increases in absolute differences in prices obtained comparing absolute differences between Canadian markets in March-June 2019 and March-June 2020. Increases for more than 50% of F&V commodities are shaded in red.

This means that for two-thirds of F&V commodities sold in both Montreal and Toronto, the differences in prices observed in different markets intensified during the pandemic, contributing to create economic distance between geographically distant markets.

Similar conclusions are obtained for the two Mexican markets studied, where 75% of F&V commodities reported an increase in absolute differences in prices both between Mexico City and Guadalajara and between Mexico City and Monterrey. Guadalajara and Monterrey were geographically and economically more distant during the initial months of the pandemic, with

81% of F&V commodities reporting an increase in absolute differences in prices between the periods March-June 2019 and March-June 2020 (table 10). Almost all F&V commodities reported an increase in the price level and in price volatility during March-June 2020 as compared to March-June 2019. It is worth noting that the pandemic is still ongoing in Mexico, and the curve of infections shows no signs of abating at the time of writing (see fig. A.3 in Appendix A.1.3).

Table 9. Percentage of products reporting an increase in absolute differences in prices between Mexican markets.

MEX	Guadalajara	Mexico City	Monterrey
Guadalajara			
Mexico City	75%		
Monterrey	81%	75%	

Source: Elaboration on data from USDA.
Notes: Absolute differences in prices between Mexican markets computed for periods March-June 2019 and March-June 2020. Increases in absolute differences in prices obtained comparing absolute differences between Mexican markets in March-June 2019 and March-June 2020. Increases for more than 50% of F&Vs commodities in red.

US markets seemed more integrated. The percentage of F&V commodities reporting an increase in absolute differences in prices between pairs of US markets was on average 47% (±9%) across 66 pairs of US markets. More than 60% of pairs of US markets (41 of 66) showed increases in absolute differences in prices for less than half of the commodities studied. Among the remaining pairs of US markets (25 of 66), for which more than half of F&V commodities reported an increase in absolute differences in prices, markets that stand out include Los Angeles (7 out of 11 US markets), New York (6 out of 11), and Miami and Atlanta (5 out of 11 for both) (table 11). Several of these markets are located in States that are among the most affected by the pandemic (see fig. A.2 of Appendix A.1.2).

In the EU, polar cases were frequent. F&V markets in the EU are not highly integrated (Santeramo, 2015) with respect to the US. However, having food production, processing, and distribution that are rather spread across the continent may be viewed as a factor contributing to the resilience of the EU food system (Wieck et al., 2020). Against 18 out of 120 pairs of EU markets that did not sell the same F&V commodities during the periods March-May 2019 and March-May 2020, 43 pairs of EU markets showed upward differences in prices for a large percentage of F&V commodities. Among them, an increase in absolute differences in prices was observed in all the F&V commodities examined: in 18 out of 43 pairs of EU markets, there were upward differences in prices for more than the half the F&V commodities. Such a marked economic distance occurred both for geographically distant country pairs (e.g. Austria-Spain, Bulgaria-Portugal, Hungary-Ireland) and proximate ones (e.g. Belgium-Czech Republic, Croatia-Hungary, Poland-Romania) (table 12). Countries harder hit by the pandemic tended to see their economic distance from other markets increase. Examples include Italy, Spain, and France, which were among the EU Member States most affected by the pandemic (see figs. A.4 and A.5 of Appendix A.1.4). Increases in absolute differences in prices of more than half the F&V commodities studied were observed in 11 of 15 EU markets for Spain, 8 of 14 for Italy, and 6 of 14 for France. An extreme opposite situation occurred in 16 of 120 pairs of EU markets for which the difference in prices is null for any F&V commodity sold in both markets. For instance, this was the case in the relationships between Croatia and the Netherlands, between Poland and Portugal, between Germany and Greece, and between Ireland and Romania (table 12).

Table 10. Percentage of products reporting an increase in absolute differences in prices between US markets.

USA	Atlanta	Baltimore	Boston	Chicago	Columbia	Dallas	Los Angeles	Miami	New York	Philadelphia	Rotterdam	San Francisco
Atlanta												
Baltimore	48%											
Boston	50%	50%										
Chicago	52%	49%	49%									
Columbia	54%	55%	53%	50%								
Dallas	53%	47%	46%	53%	38%							
Los Angeles	57%	51%	50%	48%	59%	42%						
Miami	61%	58%	55%	43%	47%	47%	57%					
New York	41%	50%	44%	46%	59%	43%	56%	52%				
Philadelphia	43%	59%	55%	57%	54%	42%	56%	46%	55%			
Rotterdam	33%	44%	38%	26%	45%	45%	56%	30%	59%	35%		
San Francisco	42%	46%	40%	54%	40%	44%	41%	41%	44%	37%	8%	

Source: Elaboration on data from USDA.

Notes: Absolute differences in prices between US markets computed for periods March-June 2019 and March-June 2020. Increases in absolute differences in prices obtained comparing absolute differences between US markets in March-June 2019 and March-June 2020. Increases for more than 50% of F&Vs commodities in red.

Table 11. Percentage of products reporting an increase in absolute differences in prices between EU markets.

EUN	Austria	Belgium	Bulgaria	Croatia	Czech	France	German.	Greece	Hungary	Ireland	Italy	Netherl.	Poland	Portugal	Romania	Spain
Austria																
Belgium	80%															
Bulgaria		100%														
Croatia	25%	50%														
Czech	25%	100%		50%												
France	33%	67%	0%	33%	67%											
German.	67%	50%		75%	40%	40%										
Greece	0%	50%	100%	75%	0%	67%	0%									
Hungary	100%	60%	100%	100%	100%	17%	75%	63%								
Ireland		0%					0%		100%							
Italy	40%	57%	100%	40%	33%	67%	17%	64%	89%							
Netherl.	100%	33%		0%		50%	50%	0%	100%		75%					
Poland	25%	60%	50%	0%	17%	33%	17%	50%	20%		20%	0%				
Portugal	0%	50%	100%	0%	25%	86%	17%	43%	20%		60%	0%	20%			
Romania	0%	100%	100%	50%	0%	50%	0%	33%	33%		33%		100%	33%		
Spain	100%	67%	100%	75%	50%	82%	40%	79%	80%	100%	67%	75%	75%	38%	33%	

Source: Elaboration on data from Eurostat.

Notes: Absolute differences in prices between EU markets computed for periods March-May 2019 and March-May 2020. Increases in absolute differences in prices obtained comparing absolute differences between EU markets in March-May 2019 and March-May 2020. Increases for more than 50% of F&Vs commodities in red.

7. Main conclusions and implications

The COVID-19 pandemic has caused and continues to cause considerable economic hardship, with significant pressures on all agri-food markets, including the F&V sector. Social distancing measures, implemented in many countries to flatten the curve of infections, have had significant economic implications at the macroeconomic and sectoral levels—particularly for the hotel, restaurant, and catering (HORECA) sector, tourism, manufacturing, and retail, including firms directly involved in agri-food and F&V markets (Gray, 2020; Goodman-Bacon and Marcus, 2020). Urgent actions implemented in response to the economic crisis, accompanied by international restrictions on travel and immigration and an international price war in crude oil, have affected the level of economic activity in North America, Europe, and other parts of the globe, with effects on price dynamics of agri-food products in general and high-value products such as F&Vs in particular (Mead et al., 2020).

Despite announcements of unprecedented government stimulus packages in Canada (i.e., improved access to credit for agri-food operators), the US (e.g. Coronavirus Food Assistance Program), and some EU countries (e.g. support to local F&V producers in Italy, Portugal, and Romania; establishment of a green corridor allowing for the mobility of guestworkers across EU borders), F&V markets have experienced generalised increases in price levels and variability.

Our analysis reveals that the US tended to experience a surge in both the level and volatility of F&V prices, with the most affected markets being Rotterdam (+15% in price level) and New York (+617% in price deviation). It is worth noting that the State of New York, where the New York City and Rotterdam markets are located, is one of the US States that was most affected by the pandemic, with a total of 442,060 COVID-19 cases as of early August 2020. The price effects were even more pronounced in Mexico, with almost all F&V commodities reporting an increase in price level and volatility during March-June 2020 as compared to March-June 2019, and where the pandemic is still ongoing and the curve of infections shows no signs of abating. Although the Canadian markets of both Montreal and Toronto saw a reduction in F&V price levels, almost half of the F&V commodities studied experienced a price increase. Overall, we found that, while US markets seem more integrated, for more than two-thirds of the F&V commodities sold in the Canadian and Mexican markets studied, the differences in prices observed in pairs of markets intensified during the pandemic, widening the economic distance between geographically distant markets.

In the EU, price levels suffered from a generalised increase (from +3% in Ireland to +56% in Poland), whereas deviations in prices tended to decrease, with some exceptions (i.e. +87% in Portugal, +82% in France, +40% in the Netherlands). Polar outcomes were frequent. While in some cases, the difference in prices between pairs of EU markets was null for F&V commodities sold in both markets (e.g. Croatia-Netherlands, Poland-Portugal, Germany-Greece, Ireland-Romania), countries harder hit by the pandemic tended to see their economic distance from other national markets increase. Examples include Italy, Spain, and France, which were among the EU countries most affected by the pandemic.

Overall, we found that the increase in the prices of fruit and nuts was greater than the corresponding increase for vegetables, roots, and tubers. This was the case both in North America and in Europe, but it was likely to have had a high impact on markets that heavily rely on imports of fruit and nuts such as Canada and the US. Although borders remained open to trade during the crisis, restrictions on the cross-border movement of people appeared to have consequences for import-dependent stakeholders in Canadian and US F&V value chains. For F&V

producers, migrant labour is critically important, especially in the United States and Canada (Barichello, 2020). Growers who could no longer rely on a ready supply of guestworkers, in particular from Mexico, could not conduct early-season planning for the coming harvest, even though the pandemic began to spread before the harvest season for most F&Vs (Schmidhuber et al., 2020). Indeed, planting decisions were made before the onset of the pandemic, potentially leading to an oversupply of F&Vs in the short run and a consequent increased stock of low-perishable commodities (Gay et al., 2020). Therefore, F&V prices are likely to be affected by changes in the cost of production, with effects observable also in the long run (Richards and Rickard, 2020).

Our results also showed that less perishable F&V commodities were the most affected by price surges and variability. This tendency was quite evident in the Canadian, US, and EU markets studied. The impact of COVID-19 on wholesale and retail markets was particularly visible for F&Vs: perishability separates the fresh produce industry from most other agricultural sectors (Richards and Rickard, 2020). During the pandemic, demand for less perishable commodities was supported by consumers who were eating at home much more frequently and thus needed to restock their pantries (Gray, 2020). Indeed, Canada, the US, and EU experienced some hoarding during the pandemic, and consumers, worried about possible shortages in food stores, tended to stockpile non-perishable foods (Richards and Rickard, 2020).

The challenges that the agri-food sector in general and the F&V sector in particular face in the context of the COVID-19 pandemic are enormous. In the short run, the F&V sector has managed to keep the availability of product at close to normal levels and for the most part avoid shortages, but producers accustomed to supplying fresh products to restaurants and farmers' markets have been severely damaged (Orden, 2020). In the medium to long term, the challenges for the F&V sector are mostly related to labour availability, given that the US and Canada heavily rely on guestworkers from Mexico and to a lesser extent, other countries. Similarly, F&V producers in southwestern EU countries depend on guestworkers from countries in Eastern Europe (Schmidhuber et al., 2020).

International trade has played an important role in managing and avoiding potential disruptions of F&V supply chains in the medium to long term because of the pandemic (Elleby et al., 2020). As suggested in Martin and Anderson (2011), export restrictions and import subsidies should be avoided, and standards should be pro-trade, rather than barriers, as indeed happens in most cases (Santeramo and Lamonaca, 2020). Indeed, such remedies implemented to limit the effects of the global food price crisis in 2007/08 proved to be inefficient and ultimately detrimental at both the domestic and international levels. Instead, efforts should be made to lower trade barriers for the commodities most affected by effects of the pandemic, such as F&Vs.

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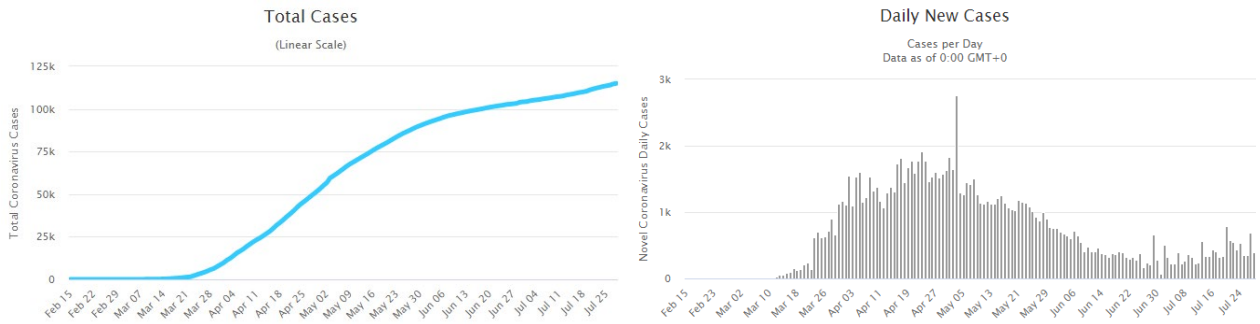
A. Appendix

A.1. Trends in COVID-19 pandemic in selected countries

A.1.1. Pandemic in Canada

According to the Worldometers data, on July 29, 2020, the number of COVID-19 cases in Canada totaled 115,470. Active cases were 5,948, of which 62% (3,711) were currently infected patients in mild condition and the remaining 38% (2,237) were currently infected patients in serious or critical condition. Cases which had an outcome totaled 109,046, of which 92% (100,134) had recovered or were discharged, and the remaining 8% (8,912) were deaths. Figure A.1 shows trends in total and daily new COVID-19 cases in Canada.

Figure A.1. Total and daily new COVID-19 cases in Canada.

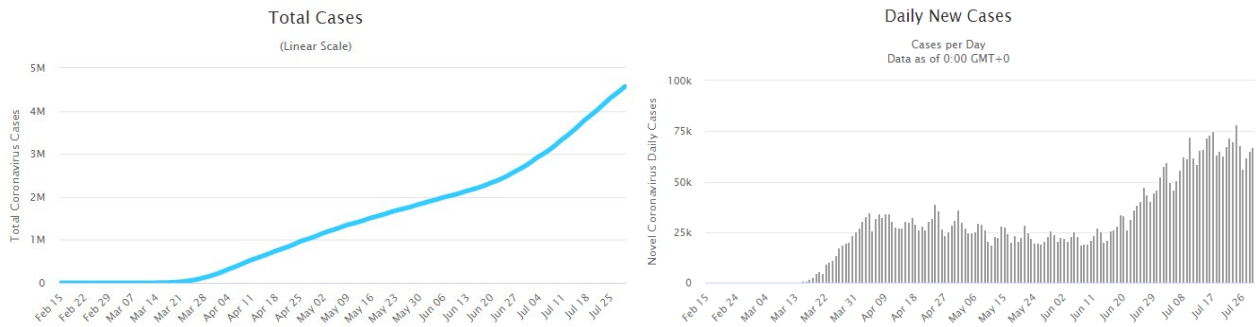


Source: data from Worldometers.

A.1.2. Pandemic in the United States

According to the Worldometers data, on July 29, 2020, COVID-19 cases in the US totaled 4,568,375. The five most affected States were California (487,478 total cases), Florida (451,423), New York (442,060), Texas (424,433), and Georgia (178,323). Active cases in the US totaled 2,169,009. Cases which had an outcome numbered 2,399,366, of which 94% (2,245,521) were recovered or discharged and the remaining 6% (153,845) were deaths. Figure A.2 shows trends in total and daily new COVID-19 cases in the US.

Figure A.2. Total and daily new COVID-19 cases in the United States.

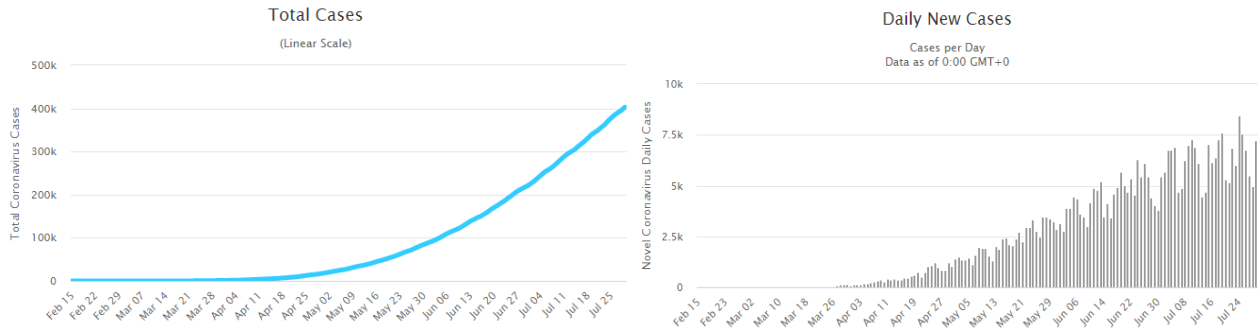


Source: data from Worldometers.

A.1.3. Pandemic in Mexico

According to the Worldometers data, on July 29, 2020, COVID-19 cases in Mexico totaled 408,449. Active cases numbered 96,364; cases which had an outcome equaled 312,508, of which 85% (267,147) were recovered or discharged and the remaining 15% (45,361) were deaths. Figure A.3 shows trends in total and daily new COVID-19 cases in Mexico.

Figure A.3. Total and daily new COVID-19 cases in Mexico.

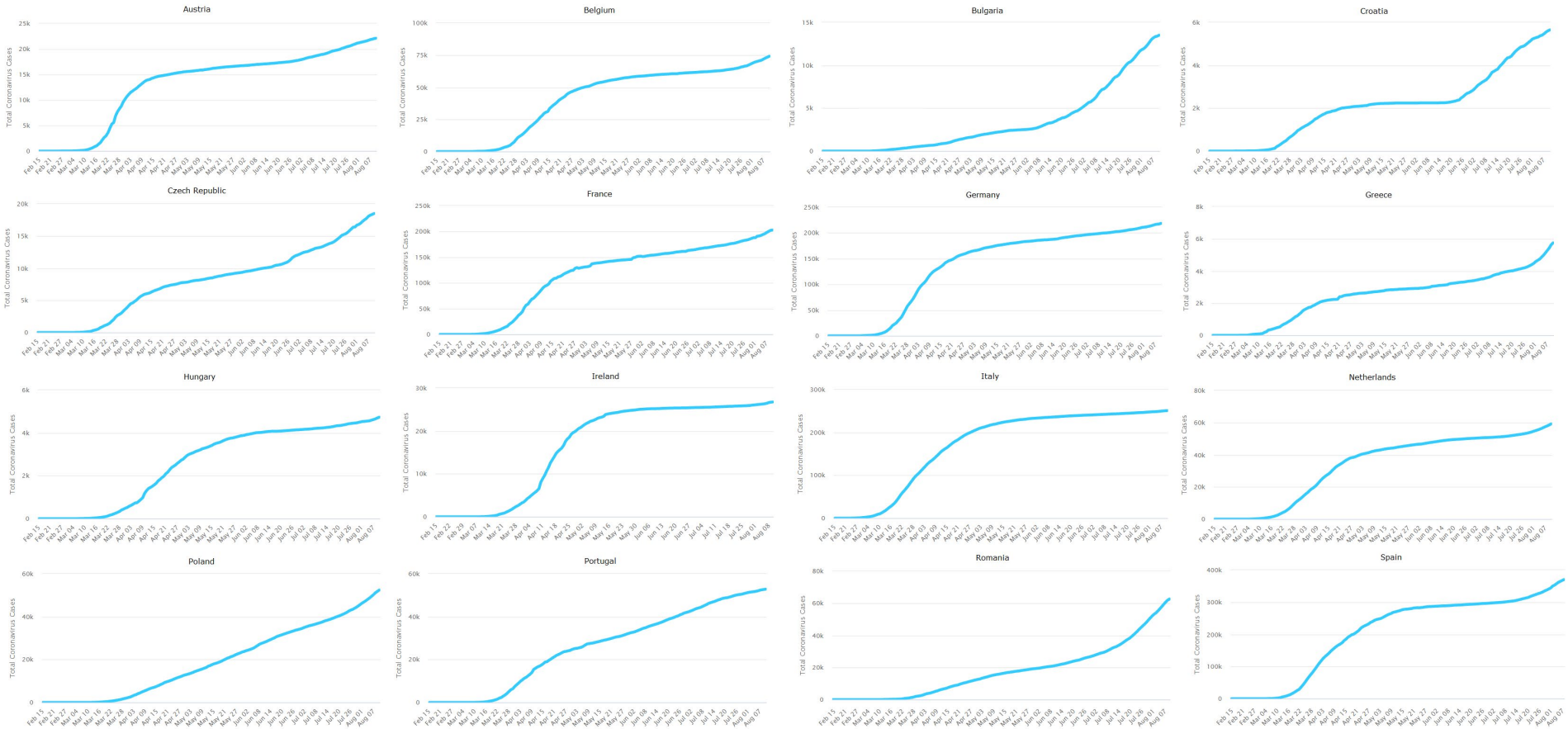


Source: data from Worldometers.

A.1.4. Pandemic in the European Union

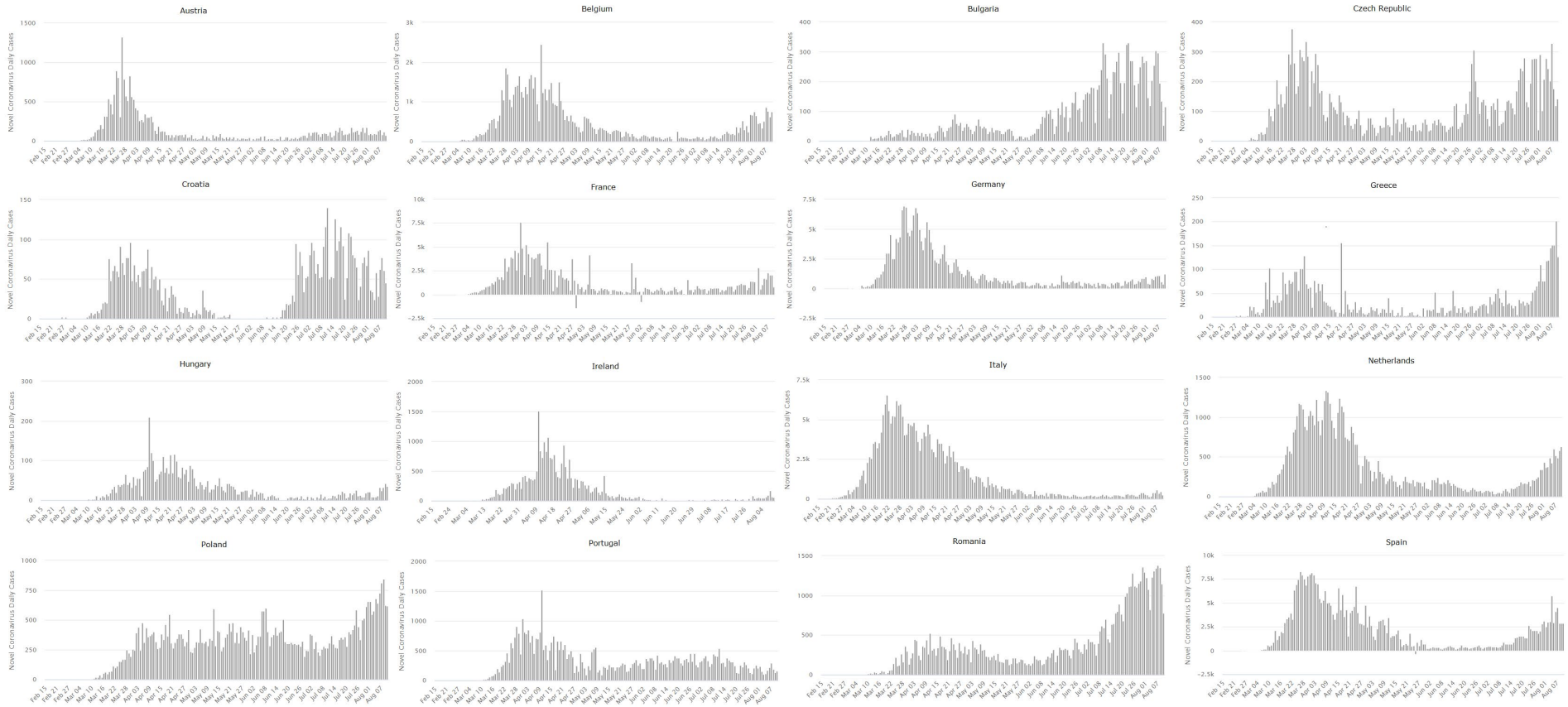
According to the Worldometers data, on August 11, 2020, Europe (United Kingdom and Russia included) had a total of 3,071,619 COVID-19 cases. The most affected EU Member States were Spain (370,060 total cases), Italy (250,825), Germany (218,500), and France (202,775). Among the EU Member States with fewer cases were Greece, Croatia, and Hungary, with 5,749, 5,649 and 4,746 total cases, respectively. Currently infected patients in Europe numbered 1,019,767, most of which were in EU Member States such as Spain (144,526 active cases) and France (89,599), whereas Hungary and Croatia were among the Member States with the fewest active cases (614 and 585, respectively). Recovered or discharged patients in Europe totaled 1,845,275, of which 11.0% were in Italy, 10.8% in Germany, and 4.5% in France. Total deaths in Europe equaled 206,577, of which 17.0% were in Italy, 14.7% in France, 13.8% in Spain. Figures A.4 and A.5 show trends in total and daily new COVID-19 cases in selected EU countries.

Figure A.4. Total COVID-19 cases in selected EU countries.



Source: Data from Worldometers.

Figure A.5. Daily new COVID-19 cases in selected EU countries.



Source: Data from Worldometers.

A.2. Policy measures implemented to combat the pandemic

Table A.1 lists F&Vs according to their perishability. We collected shelf-life data for different types of F&Vs from Gross et al. (2016) and considered the optimum storage conditions (by temperature or controlled atmosphere) to assign grades of perishability (Kader, 2020): high-perishable (up to 1 month), medium-perishable (1-6 months), and low-perishable (more than 6 months).

Table A.1. Policy measures and urgent actions implemented in selected countries to limit effects of the pandemic.

High-perishable commodity (<1 month)	**Medium-perishable commodity** (1-6 months)	**Low-perishable commodity** (>6 months)
Artichokes	Blueberries	Apples
Asparagus	Cabbage	Carrots
Avocados	Celery	Celeriac (celery root)
Beans	Chinese cabbage	Dates
Beets	Coconuts	Horseradish
Blackberries	Cranberries	Jerusalem artichokes
Breadfruit	Garlic	Peanuts
Broccoli	Ginger root	Pecans
Brussels sprouts	Grapefruit	Pistachios
Carambola	Jicama root	Potatoes
Cauliflower	Kiwi fruit	Sweet potatoes
Cherimoya	Kohlrabi	Tamarindo
Cherries	Leeks	Walnuts
Corn-sweet	Lemons	
Cucumbers	Limes	
Dragon fruit (red pitaya)	Mangosteen	
Eggplant	Olives	
Endive	Onions	
Escarole	Oranges	
Figs	Parsley	
Grapes	Parsnips	
Guava	Peaches	
Honeydews	Pears	
Lettuce	Persimmons	
Longan	Pomegranates	
Loquats	Pumpkins	
Mandarins	Quinces	
Mangoes	Rutabagas	
Mushrooms	Salsify	
Nectarines	Swiss Chard	
Okra	Tamarillo	
Papaya	Taro	
Passion fruit	Tomatoes	
Peas	Turnips	
Peppers	Water chestnuts	
Pineapples		
Plums		
Radicchio		
Radishes		
Rambutan		
Raspberries		
Rhubarb		
Squash		
Strawberries		
Tangerines		
Tomatillos		
Watercress		
Watermelons		

A.3. Policy measures implemented to combat the pandemic

Table A.2 lists the policy interventions and urgent measures implemented by the governments of Canada, United States, Mexico, and the 16 EU countries in our study in order to limit the effects of the pandemic. Table A.2 indicates the dates when these measures became effective

and assigns them to a specific class of interventions, indicating the intended beneficiaries of the policy.

Table A.2. Policy measures and urgent actions implemented in selected countries to limit effects of the pandemic.

Date	Policy classification	Beneficiaries
Canada		
Mar 23, 2020	Access to credit / Financial support through public banks	Food industry, agricultural producers
United States		
May 19, 2020	In-kind food transfer / Direct payments to agricultural producers	Agricultural producers, needy people
May 19, 2020	Financial support through public banks / Unspecified risk management measures	Agricultural producers
May 04, 2020	Renewable energy and energy efficiency measures / Support to productive assets	
Apr 09, 2020	Access to credit / Financial support through public banks	Companies of up 10,000 employees
Mar 27, 2020	Unconditional cash transfer /Unemployment compensation	Citizens without work, companies, states, cities
European Union		
Austria		
Apr 03, 2020	Credit for consumption / Access to credit	Consumers, companies
Mar 21, 2020	Agricultural expenditure in the national budget / National market information system	Workers, unemployed, farms
Bulgaria		
Apr 24, 2020	Employment programmes / Financial support through public banks	Companies
Mar 20, 2020	Unemployment compensation /Employment programmes	Companies
Croatia		
Mar 17, 2020	Financial support through public banks / Production subsidies	Fisheries sector
Mar 17, 2020	Price control	Citizens
Mar 17, 2020	Employment programmes / Financial support through public banks	Workers
Czech Republic		
May 26, 2020	Agricultural expenditure in the national budget	Agricultural producers
France		
Jul 20, 2020	Sanitation and hygiene	Citizens
Jun 02, 2020	Unspecified agricultural tax	Companies
May 27, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies
May 11, 2020	Institutional measure / Public institution	Schools
Apr 17, 2020	Unspecified agricultural tax / Farm income tax	
Apr 16, 2020	Unspecified production support / Access to credit	Companies, unemployed, citizens
Apr 16, 2020	Unconditional cash transfer	Needy people
Apr 15, 2020	Food coupons / Conditional cash transfer (CCT)	Needy people
Apr 08, 2020	Import ban	
Apr 07, 2020	Food coupons	Civilian and military personnel
Apr 05, 2020	Institutional measure	
Apr 02, 2020	Public/mutual fund and contingent risk financing	Companies
Apr 01, 2020	Institutional measure	
Mar 31, 2020	Subsidies on fuel, power and water	Professional premises
Mar 30, 2020	Unspecified production support / Public/mutual fund and contingent risk financing	Companies, self-employed workers
Mar 30, 2020	Institutional measure	
Mar 24, 2020	Institutional measure	Workers
Mar 23, 2020	General nutrition and health interventions	
Mar 18, 2020	General social protection measures / Unspecified production support	Companies, self-employed
Mar 18, 2020	Unconditional cash transfer / Access to credit	Companies, self-employed

Mar 18, 2020	Unemployment compensation	Unemployed
Mar, 2020	Nutrition and health policy / Public/ mutual fund and contingent risk financing	Healthcare system, health workers
Mar 16, 2020	Institutional measure	Citizens
Germany		
Jun 04, 2020	Value-added tax (VAT) / Climate change mitigation and adaptation measures	
Mar 23, 2020	Employment programmes / National market information system	Farms and agricultural workers
Mar 23, 2020	Financial support through public banks / Production subsidies	Companies
Greece		
Mar 12, 2020	Value-added tax (VAT) / Production subsidies	Companies
Hungary		
Apr 08, 2020	Financial support through public banks / Agricultural expenditure in the national budget	Companies
Ireland		
May 02, 2020	Farm income tax / Access to credit	Companies
Mar 09, 2020	Unemployment compensation /Financial support through public banks	Workers and self-employed
Italy		
Jul 16, 2020	Institutional measure / Transport regulation and infrastructure	Travellers
Jul 14, 2020	Institutional measure	
Jun 11, 2020	Institutional measure	Travellers, citizens
May 19, 2020	Unconditional cash transfer	Needy people
May 19, 2020	General social protection measures /Unspecified production support	Family and companies
May 19, 2020	Unconditional cash transfer	Needy people
May 19, 2020	Unconditional cash transfer	Self-employed and professional workers
May 19, 2020	Unconditional cash transfer	Private-sector workers
May 19, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies
May 19, 2020	Value-added tax (VAT) / Unspecified agricultural tax	
May 19, 2020	?	Tourism and culture sector
May 19, 2020	General social protection measures / Employment programmes	Citizens
May 19, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies
May 18, 2020	Institutional measure	Travellers
Apr 30, 2020	Nutrition and health policy / Institutional measure	
Apr 26, 2020	Institutional measure	Travellers, citizens, workers
Apr 08, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies
Apr 01, 2020	Institutional measure	
Mar 31, 2020	General social protection measures / Nutrition and health policy	
Mar 29, 2020	In-kind food transfer / Food coupons	Needy people
Mar 25, 2020	General social protection measures / Nutrition and health policy	Healthcare system
Mar 25, 2020	Institutional measure / Public institution	Travellers, schools, market, mass gathering, bars and restaurants
Mar 25, 2020	Credit for consumption / Public/mutual fund and contingent risk financing	
Mar 20, 2020	Unspecified credit and finance facility	Banks
Mar 17, 2020	Conditional cash transfer (CCT)	Needy people
Mar 17, 2020	Access to credit	Companies
Mar 17, 2020	Access to credit / Financial support through public banks	Companies
Mar 17, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies

Mar 16, 2020	General social protection measures / Unspecified production support	Citizens, healtcare system, workers
Mar 16, 2020	General social protection measures / Nutrition and health policy	Healthcare system, civil protection department and law enforcement bodies
Mar 16, 2020	Unemployment compensation	Workers, families
Mar 16, 2020	Unspecified credit and finance facility	Companies, families
Mar 16, 2020	Unspecified tax policy	Workers, companies
Mar 16, 2020	Conditional cash transfer (CCT)	Workers and self-employed workers
Mar 16, 2020	General social protection measures / Conditional cash transfer (CCT)	Workers, families
Mar 16, 2020	Unspecified disposable income policy	Workers
Mar 16, 2020	Unemployment compensation	Workers
Mar 16, 2020	Agricultural expenditure in the national budget / Public/mutual fund and contingent risk financing	Agriculture and fishing
Mar 16, 2020	Food coupons	Needy people
Mar 12, 2020	Institutional measure	
Mar 11, 2020	Institutional measure	Commercial activities
Mar 09, 2020	Institutional measure	Citizens
Mar 08, 2020	Institutional measure	
Mar 02, 2020	Access to credit / Public/mutual fund and contingent risk financing	Companies
Feb 29, 2020	Credit for consumption / Access to credit	
Feb 24, 2020	Unspecified tax policy / Tax on inputs or fixed capital	Taxpayers
Feb 23, 2020	Nutrition and health policy / Institutional measure	
Jan 31, 2020	Institutional measure	
Netherlands		
Apr 07, 2020	Employment programmes	Companies
Mar 24, 2020	Soup kitchen and food pantries / Public/mutual fund and contingent risk financing	?
Poland		
Apr 03, 2020	Access to credit / Financial support through public banks	Food industry, agricultural markets
Portugal		
Jun 04, 2020	Employment programmes / Access to credit	Companies
Mar 30, 2020	Promotion of farmer markets or community markets	Farmers and producers
Mar 23, 2020	Access to credit / Insurance and reinsurance	
Romania		
Mar 19, 2020	Employment programmes / Access to credit	Companies
Mar 13, 2020	Technical assistance, extension and training / Production subsidies	Farmers and producers
Spain		
May 29, 2020	Unconditional cash transfer	Needy people
May 09, 2020	Public institution	
May 09, 2020	Price control / Transport regulation and infrastructure	Travellers
Apr 01, 2020	Credit for consumption	Needy people
Apr 01, 2020	Credit for consumption	
Apr 01, 2020	Credit for consumption	
Apr 01, 2020	Tax on fuel and water	Needy people
Apr 01, 2020	Unemployment compensation	Domestic workers
Apr 01, 2020	Financial support through public banks	Self-employed
Apr 01, 2020	Public/mutual fund and contingent risk financing	Companies
Apr 01, 2020	Fuel resources for production / Financial support through public banks	Self-employed, companies
Apr 01, 2020	Public institution	
Apr 01, 2020	Employment programmes / Agriculture research and technology	Researchers
Apr 01, 2020	Unspecified government market intervention / Processing and postproduction facilities	
Apr 01, 2020	Unemployment compensation	Workers with temporary contract
Mar 30, 2020	Unemployment compensation / Employment programmes	Workers

Mar 27, 2020	Price control / Transport regulation and infrastructure
Mar 25, 2020	Livestock measures and regulations / Transport regulation and infrastructure
Mar 14, 2020	Unspecified institutional measure

Source: Elaboration on data from FAPDA.