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Effects of COVID-19 on the Italian agri-food supply and value chains

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ABSTRACT

The spread of COVID-19 has not only led to many deaths but also to social and economic downturn globally. The study represents an exhaustive compilation of relevant macroeconomic data regarding the status of the agri-food sector from a demand side perspective and an overview of the food product producer and consumer prices after the shock. Its main purpose is to assess the resilience level of the agri-food sector to the coronavirus pandemic, analyzing its effect on commodity prices and focusing on the supply and value chain. The results highlight that fresh and perishable products, whose production or harvest took place during the first wave of COVID-19, have suffered price level effects, while storable products have not registered significant impacts. This phenomenon is mainly due to the vulnerability of the harvest and production phases, which affected fresh and perishable products supply, and to the resilience of transports and logistics, which instead ensured the supply of storable products to the final consumer. Especially in case of future pandemic waves, the implications and information deriving from the present analysis could support researchers, policy makers and managers, serving as an assessment tool to build suitable strategies for the whole agri-food supply chain and thus ensure sector resilience during these unprecedented times.

1. Introduction

The coronavirus pandemic has caused a state of panic worldwide, challenging food security, agriculture and food systems (Deaton & Deaton, 2020; Galanakis, 2020). Where most businesses were completely closed following governments restrictions, the food sector, as part of the national critical infrastructures, remained operational across the supply chain in order to feed the people (CISA, 2020). This sector continues to face new challenges during the global coronavirus pandemic, from supply chain disruption with its consequences on food systems (Galanakis, 2020), to meeting the high market demand, to protecting its workforce, while avoiding transportation network disturbances and absenteeism and maintaining a high level of food safety and consumer confidence (Hailu, 2020; McEwan et al., 2020; Nakat & Bou-Mitri, 2021; Weersink, 2020). Regarding food safety although there is no evidence that food is a possible route of transmission, the possibility of transmission of COVID-19 through the food supply must not be neglected, both for the risks associated with the presence of the virus in the workplace and for the risks associated to the possibility that Coronavirus may reach food products or food packaging through an infected person (Rizou et al., 2020). COVID-19 has forced companies to re-evaluate risks and opportunities, to redefine priorities and to adjust their processes both to ensure high levels of safety for workers and to provide consumer confidence and reassurance to all stakeholders (Nakat & Bou-Mitri, 2021) and local government administrators must also help by providing correct information, educational messages and timely updates to reduce fear and build trust in citizens (Faour-Klingbeil et al., 2021).

The perception of risk from touching contaminated surfaces and food packaging and being exposed to infected people during food shopping is high (Fiorillo et al., 2020). Consumption patterns have also changed. Meal preparation and consumption at home has substituted the eating out (Faour-Klingbeil et al., 2021).

The trade of commodities among countries has been disrupted; accordingly, import of raw materials and exportation of food products has been stopped (Gray, 2020). The pandemic has influenced certain food supplies more than others. For this reason, significant trade restriction policies are to be expected, in the form of more costly inspections, strict regulations and protectionist's measures from competing producers (Nakat & Bou-Mitri, 2021).

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It has been reported that in Canada the supply chains for fruits and vegetables have been the most relevantly impacted as produce growers and distributors have been obliged to change their supplies almost completely (Richards & Rickard, 2020), having been challenged by labor availability and logistical constraints. The dairy, poultry and egg sectors have also been affected by the closure of processing facilities leading to the dumping of most of their products (Weersink, 2020), while the cattle/beef supply chain has adapted more easily to the COVID-19 pandemic, thanks to the past experience of the Bovine Spongiform Encephalopathy (BSE) in 2003 (Rude, 2020).

Some countries still have adequate food supplies for the short term, but it is predicted that food insecurity will increase over intermediate and longer time periods particularly in developing countries (Deaton & Deaton, 2020).

Currently, the World Health Organization (WHO), whose data is refreshed every 15 min, reports that as of September 10, 2020 there are around 37.3 million cases. Italy has had 1.964.054 confirmed cases according to the Istituto Superiore di Sanità 2020 (ISS, Italy) as of December 22, and 69.214 deaths, ranking third in Europe and eighth in the world for number of cases while first in Europe and fifth in the world for number of deaths (John Hopkins University, 2020).The aim of this study is to verify the resilience level of the agri-food sector to the coronavirus pandemic, analyzing its effect on commodity prices and focusing on the supply and value chain. In particular, section 2 provides the background of the study with an overview of the measures adopted in Italy during the evolution of the COVID-19 pandemic. Section 3 analyzes the effects on the agri-food demand, focusing on the export values, producer and consumer price indexes of different agri-food product categories. Section 4 describes the effects of coronavirus spreading on the agri-food supply chain services, such as logistics and transportation; while section 5 illustrates and discusses the long run changes. Section 6 concludes and provides some implications of the study.

2. Study overview

2.1. Background

On December 31, 2019, the Wuhan Municipal Health Commission (China) reported a cluster of pneumonia cases of unknown aetiology in the city of Wuhan to the World Health Organization (WHO). On January 9, 2020, a new coronavirus (SARS-CoV-2) was identified as the causative agent of the respiratory disease, then named COVID-19. On January 30, 2020, the WHO declared the Coronavirus epidemic in China and on March 11 it defined the spread of COVID-19 no longer as an epidemic confined to specific geographical areas, but a widespread global pandemic.

Fig. 1 summarizes the major events that marked the spread of the pandemic in Italy during the so-called "first wave" and the main measures implemented by the Italian government to limit infections.

As can be seen, in Italy, an outbreak of COVID-19 infections was identified on February 21, 2020 starting from 16 confirmed cases in Lombardy, which increased to 60 the next day, with the first deaths reported in the same days. On 23 February, the Council of Ministers issued the decree-law n. 6, which established the total closure and isolation of municipalities with active outbreaks with the suspension of events and the interruption of railway services. The restrictive measures were extended to the whole national territory with the decree of 9 March, which forbade any movement between and within the regions, except for proven health reasons or for work needs and several closures were imposed (schools, gyms, museums, cinemas, theaters …). That decree marked the beginning of the Italian lockdown, and, in particular, of the so-called "Phase 1" of the restrictive measures put in place by the government to contain the pandemic.

On 11 March, the "#IoRestoaCasa Decree" was published, which provided for the suspension of common retail commercial activities, educational activities, catering services, and prohibited the gathering of people in public places or places open to the public. On March 22, 2020, the Prime Minister published a new decree implementing more stringent measures that provided for the closure of all those activities not deemed necessary for the Italian production chain in relation to the contingent

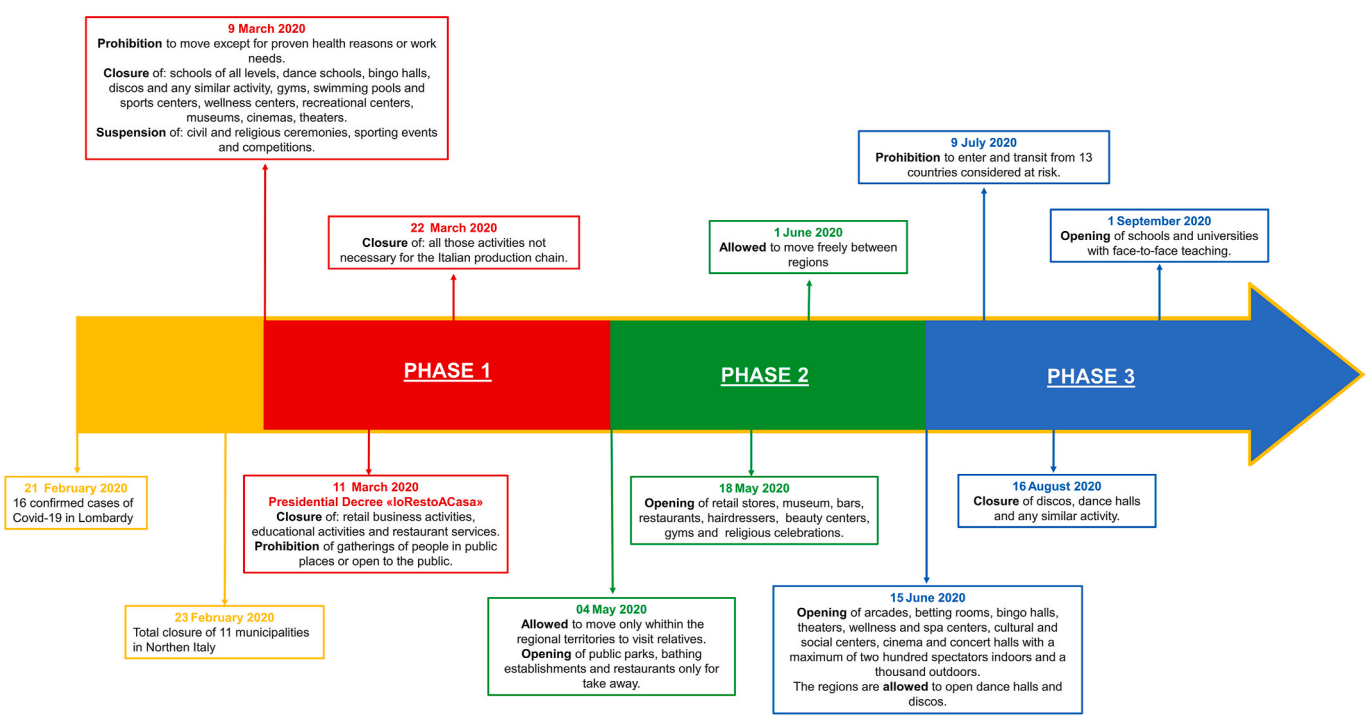

Fig. 1. The timeline of measures adopted in Italy during the evolution of the first wave COVID-19 pandemic.

situation. In companies where the activities were not suspended, measures were imposed to combat and contain the spread of the virus in the workplace such as: closure to the public, use of masks, sanitizing gels and imposed safety distance.

The measures adopted were further extended until 13 April with a new Ministerial Decree, and thereafter until 3 May.

With the decree issued on May 4, 2020, since the epidemic curve was in a downward phase, the beginning of the "Phase 2" was declared, with a gradual relaxation of the previous containment measures. Starting from 18 May, all retail trade activities were reopened together with restaurants and bars and shortly afterwards free movement between the regions was allowed, also enabling the start of national tourism.

"Phase 3" began on 15 June, with further easing and openings both nationally and regionally, despite the state of emergency being extended until January 31, 2021.

2.2. Methodology

As illustrated in Fig. 2, the study methodological framework consists primarily of a systematic data collection from relevant institutional databases and/or reports (i.e. ISTAT, ISMEA, COEWEB and COLDIRETTI) with an initial date of March 2019 and an end date of July/August 2020.

Data were considered eligible for inclusion in the analysis if they were useful to assess in particular: (i) the effects on the agri-food demand, (ii) the effects on the agri-food chain services.

Among the data extracted from the abovementioned databases and reports whose time trend was analyzed are: the retail sales value of agri-food sector, the value and share of agri-food exports, the consumer food price index, and the producer price index for some agri-food product groups. In particular, the four food groups whose producer price indexes were analyzed are: cereals, fruits and vegetables; milk, dairy products and eggs; wine and olive oil; meat products (beef cattle, sheep and goat, pigs and rabbits).

Collected data were analyzed using time series statistical methods in order to capture trends and to compare the value of variables during the "first wave" restriction time period and the same period in 2019, highlighting potentially relevant differences due to the effects of the pandemic.

The results of the analyses were interpreted and critically compared to the effects of the COVID-19 pandemic on agri-food supply and value chains observed in the existing scientific literature, constituted by a rapidly rising number of studies. This allowed the authors to identify long-run changes aimed at better facing the coronavirus pandemic and at developing new guidelines to learn from and improve upon the global response.

2.3. Effects on the agri-food demand

On the demand side, a clearly visible shock was generated by

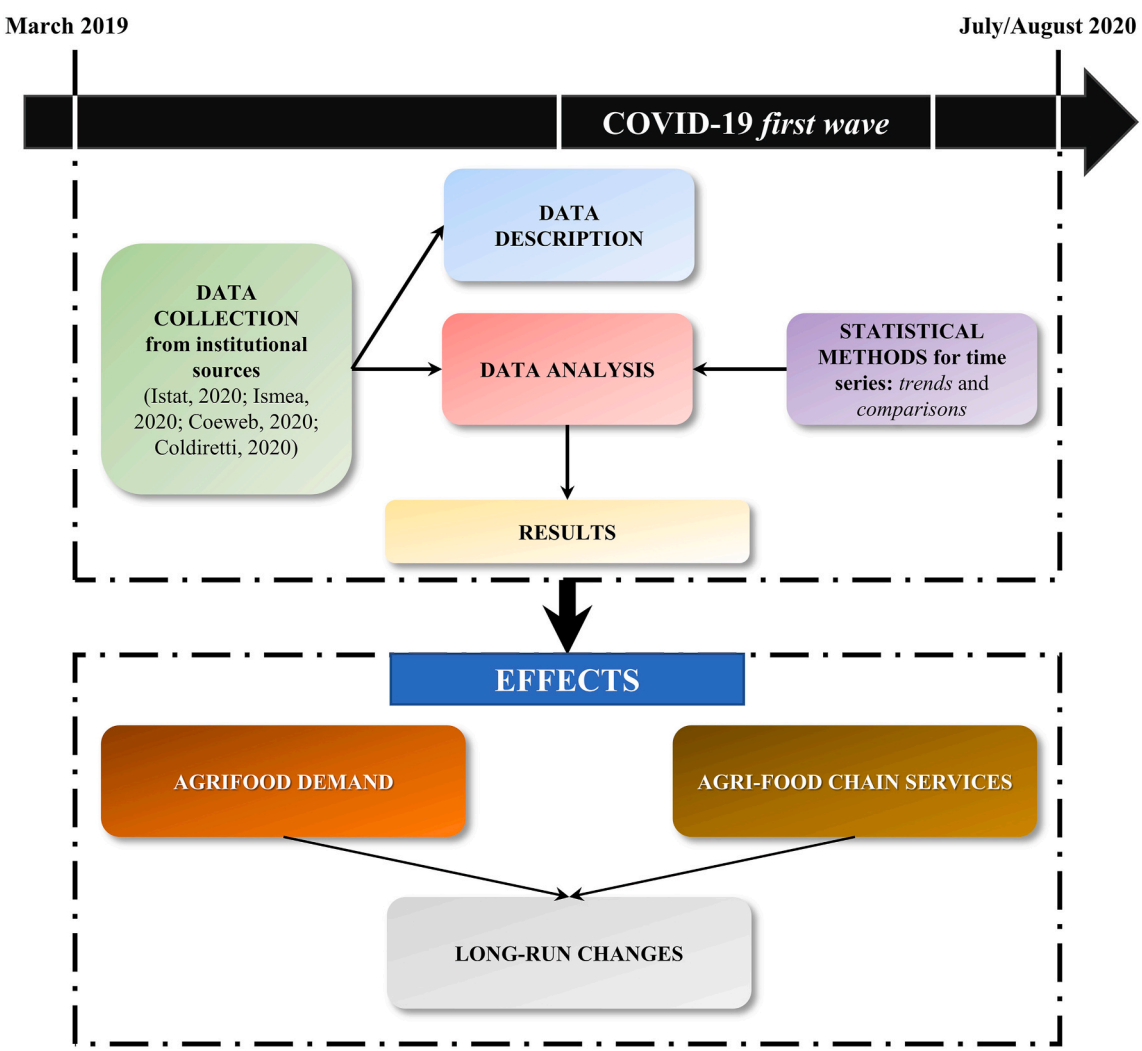

Fig. 2. Methodological framework and data processing fluxes.

changes in food purchasing and by interruption of the Horeca (Hotellerie-Restaurant-Café) channels at national and international level. Moreover, another relevant factor concerns the negative impact on export flows, due to the restrictions put in place by many countries in the world (Akter, 2020). In Italy, in fact, exports previously generated about 40% of the total turnover of the agri-food sector (ISMEA, 2018).

Analyzing the sales data extracted from the ISTAT (Italian National Institute of Statistics) for the first quarter of 2020, the agri-food sector has followed an opposite trend compared to that of the other retail sectors. In particular, comparing the data of March, April and May 2020 with those of the previous year, there was a general reduction in sales of non-food goods by about 36% in value, while sales of food goods showed positive variations (+4%)(Fig. 3) (ISTAT, 2020a).

In fact, the first phase of the COVID-19 pandemic, despite the reassurances of the food industry concerning the availability of food, was characterized by panic buying by consumers, who engaged in stockpiling behaviors in anticipation of movement restrictions and fear of disruptions to the food distribution systems (Hobbs, 2020; ISMEA, 2020a). As a result of the emergency, there was an increasing trend for the supply of conservable products (pasta, rice, canned fish, canned tomatoes, etc.) to create home stocks and a penalization of highly perishable products, replacing them with those with longer conservation times (oranges, apples, potatoes and carrots rather than strawberries, salads and asparagus) and the tendency to replace fresh products with frozen ones (Richards & Rickard, 2020; ISMEA, 2020a; ISMEA, 2020b:; ISMEA, 2020c). Studies in the literature (Bunten et al., 2020; Marty et al., 2020) show no significant changes in dietary behaviors during lockdown, except for a slight propensity towards healthy food choices, especially in overweight people and towards foods with poor nutritional quality due to mood swings. In this regard, according to Bucak and Yiğit (2020), it can be assumed that in the post-pandemic era, consumers will be led to eating healthy food with good nutritional properties.

Considering the distribution channels, during the lockdown period, small supermarkets performed best (Fig. 4). This figure can be justified by the need for citizens to avoid long journeys to comply with the security measures imposed by governments to reduce the risk of infection (Baker et al., 2020). On the other hand, large retailers, although recording positive values, were partially disadvantaged by the closure of shopping centers which generated a drop in sales in hypermarkets (ISTAT, 2020a).

In contrast to the positive trend in retail sales in the agri-food sector, in the two months of March–April, the Horeca stoppage generated a 93% drop in turnover, with estimated losses of over 34 billion euros. Therefore, the growth in retail sales (+3.1%) only partially offset the losses in non-domestic consumption (ISMEA, 2020b; 2020c).

On the export side, the effects of the lockdown have been extremely diverse depending on the countries and the commodity sectors involved. In fact, the pandemic has spread with different timing in different countries, each of which has adopted different containment measures (Vidya & Prabheesh, 2020).

Moreover, the economic effects were more important for the sectors with a greater tendency for exportation, in terms of the share of the exported turnover out of the total (fruit and vegetable processing, olive oil, rice, baked goods, pasta, coffee, chocolate, condiments and spices, ready-made meals, wine and sparkling wine) (ISMEA, 2020a; 2020b; 2020c). In particular, in the first semester of 2020, exports of agricultural products and food products increased respectively by 1% and 4% compared to 2019, obtaining a positive result despite the decline recorded in the months of March and April, especially for agricultural products (Fig. 5) (ISTAT, 2020a).

It is necessary, however, to make appropriate distinctions. Comparing the data of March, April and May 2020 with those of the previous year, there is a general negative trend as a clear consequence of the pandemic which slowed the growth recorded in the first months of the year. In particular, in Europe there was an important and generalized decline in requests for Italian products in the period analyzed. In those months, almost all of Europe suffered the squeeze of the restrictive measures imposed by governments, with closures of bars and restaurants and restrictions on travel. In particular, Germany, the first importer of Italian products, recorded the most important decline in Europe (−21% for agricultural products, −21% for food, drinks and tobacco), followed by Spain and the Netherlands. At an Extra-European level, the situation was more heterogeneous.

China and the Switzerland were the only countries analyzed to have achieved a positive trend in the months of March, April and May 2020, both for agricultural products and for drinks, food and tobacco (+23% and +18 respectively). According to Wang et al. (2020), the pandemic has changed the habits of Chinese consumers who are seeking fresher

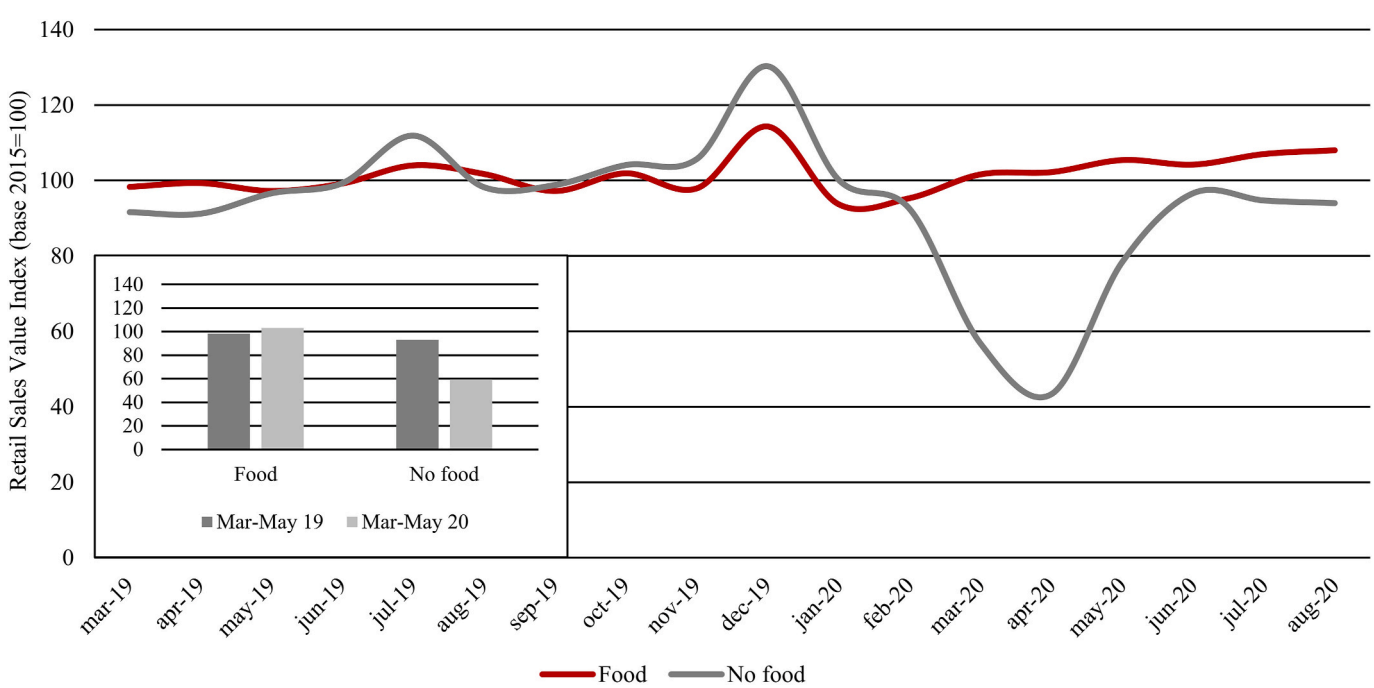

Fig. 3. Retail sales value from March 2019 to July 2020 and comparison of Mar–May 2020 vs Mar–May 2019 (base 2015 = 100).

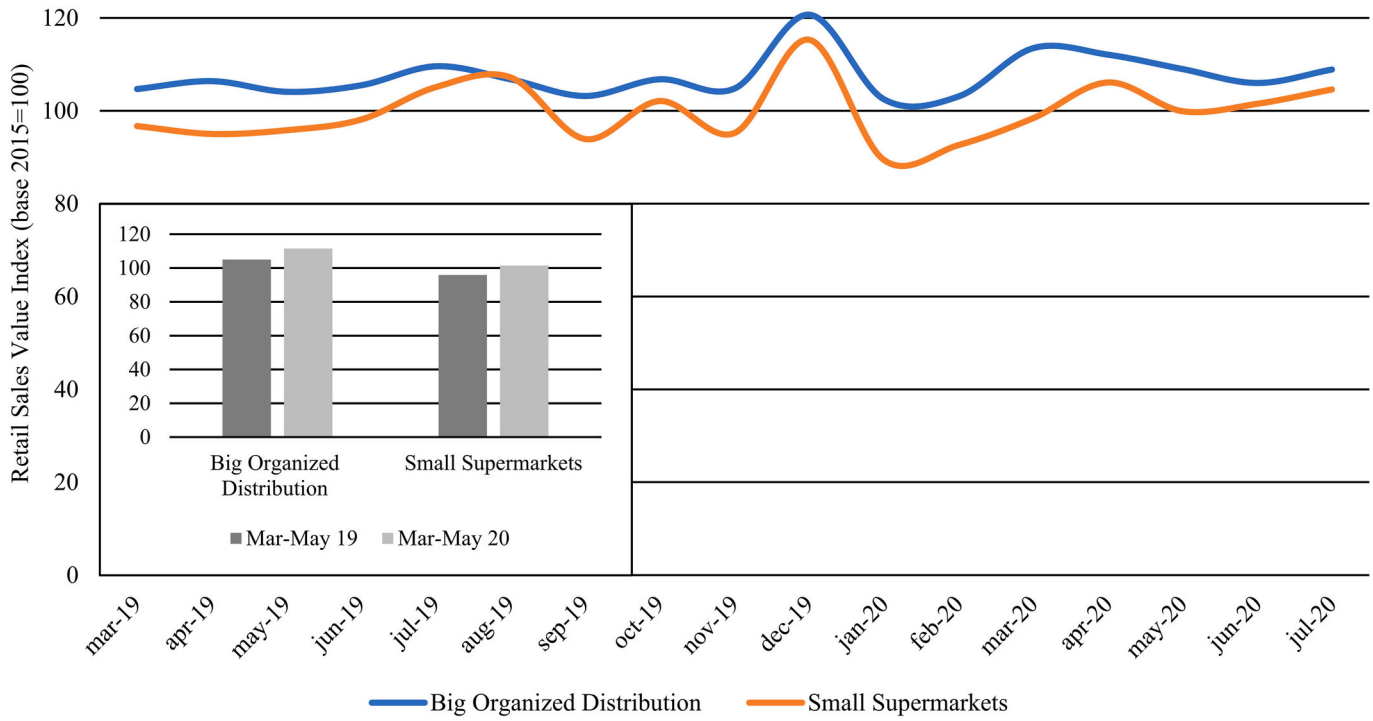

Fig. 4. Retail sales value in the food sector by distribution channel from March 2019 to July 2020 and comparison of Mar–May 2020 *vs* Mar–May 2019, (base 2015 = 100).

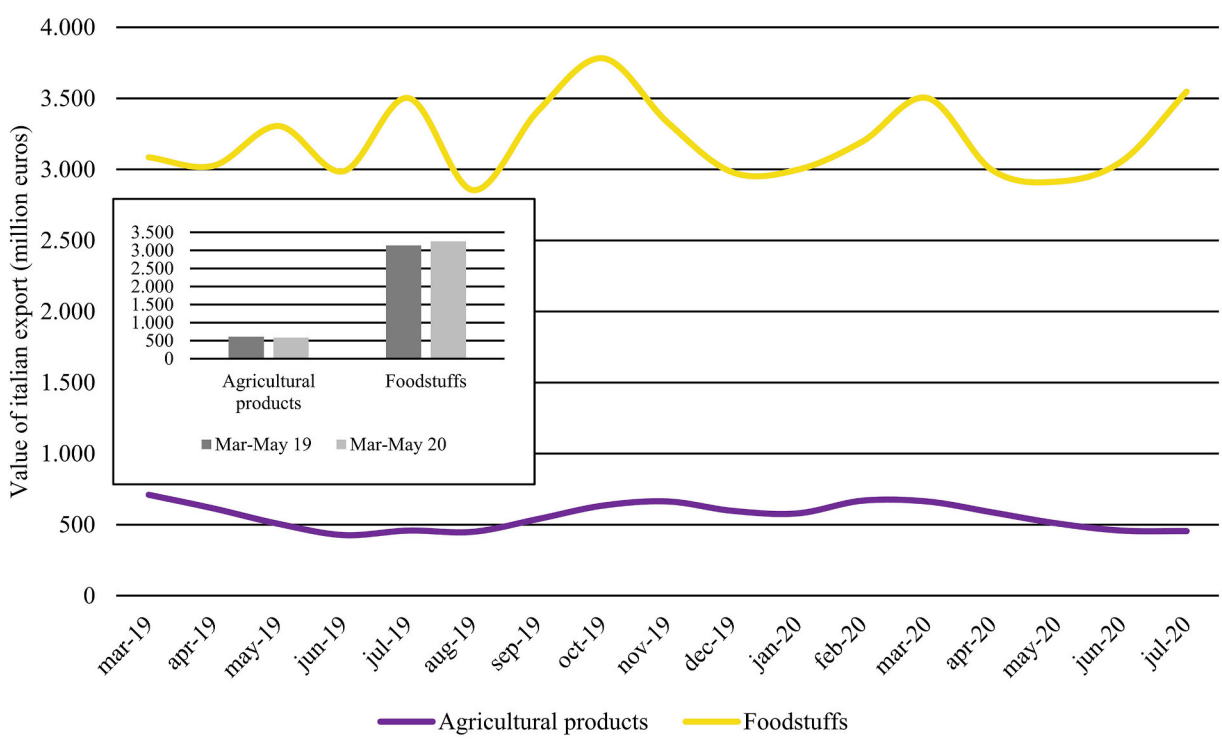

Fig. 5. Value of Italy-world export March 2019 to July 2020 and comparison of Mar–May 2020 *vs* Mar–May 2019 (million euros).

high-quality products, an opportunity that has favored the further growth of Italian agri-food products.

Japan and Turkey followed the same positive trend only for agricultural products, while the export of food, tobacco and drinks decreased. The United States, the third importer of Italian products, recorded a significant decline (−35%) in agricultural products, together with OPEC and Mercosur countries. Finally, India was the country that contributed most to the contraction of exports both for agricultural products and for food, tobacco and drinks (−72% and −33% respectively) (Table 1). In conclusion, despite the decline in the first months of the COVID-19 emergency, in the first half of 2020 the Made-in-Italy agri-food exports reached a total of 22.1 billion euros, up 3.5% on an annual basis. Since June 2020, with the generalized easing of restrictive measures, the Italian agri-food trade with foreign countries has started to

Table 1
Exports between Italy and other countries by sector of economic activity.

	Change (%) Mar–May '20 *vs* Mar–May '19	
	Agricultural, forestry and fishing products	Food, drinks and tobacco
Austria	−3%	−2%
Belgium	−11%	−2%
France	−6%	−2%
Germany	−21%	−28%
Netherland	−15%	−5%
Spain	−12%	−4%
Poland	−7%	−1%
Romania	−7%	−1%
United Kingdom	−8%	+9%
Russia	−20%	+5%
Switzerland	+19%	+2%
Turkey	+35%	−2%
United States	−35%	+1%
China	+23%	+18%
Japan	+10%	−3%
India	−72%	−33%
Opec	−23%	−6%
Mercosur	−31%	−12%

increase again (COEWEB, 2020).

The individual categories of products exported from Italy all over the world have had very different performances, reflecting the effects of the pandemic on the sector. As shown in Fig. 6, the most significant increases concern sheep meat (+38%), pig meat (+20%) and cereals (+20%), and also the foreign trade of olive oil, of which Italy is the second country in the world by volume of exports, grew by about 17%. Fruit and vegetables, despite the difficulties encountered in the harvesting phase during the lockdown, managed to obtain a growing trend.

On the other hand, there were significant decreases: flowers and plants (−39%), wine (−37%), beef and rabbit meat (−11% and −24%), eggs (−27%), milk and dairy products (−5%). The important contraction of flowers exports appears to be a clear effect of the lockdown, given their voluptuous nature and the closure of florists, cemeteries and markets. Moreover, the sharp decline of wine (−37%), where a downturn has not been recorded in over 30 years, is a consequence of the months of lockdown and in particular of the closure of bars, restaurants and hotels (Cardebat et al., 2020). This figure is particularly impressive if we consider the sharply growing trend that characterized the first months of 2020 (COEWEB, 2020).

In this context, the peaks in household food consumption, registered in the weeks of the greatest spread of infections, caused an increase in the Consumer Food Price Index (from +1.1% to + 2.7%) compared to the previous year (Fig. 7) (ISTAT, 2020a).

The phenomenon of increase in CPI for food has uniformly spread across the Italian territory. However, the islands appear to be most affected by the lockdown, which caused an increase of about 3%, compared to the data of the first quarter of 2019 (Fig. 8) (ISTAT, 2020a).

At a regional level, Liguria, Friuli Venezia Giulia, Valle d'Aosta and are the regions registering the highest increase compared to 2019 (between 3.5% and 4%). In Abruzzo and Basilicata prices appeared less sensitive to the effect of the restrictive measures implemented during the "first wave phase" (Fig. 1), with increases between 1.2% and 2.2% (ISTAT, 2020a) (Fig. 9).

The trend in consumer food prices described above, was largely offset by the collapse in energy and oil prices, which totally eliminated inflation in April (ISTAT, 2020b).

Another element to consider is the trend in producer price indexes for food, which have had uneven results between the among categories of products. In general, in the first four months of 2020, they decreased by 0.9% on an annual basis, driven down by the basket of vegetable products (−4.1%), in particular olive oil and vegetables. On the

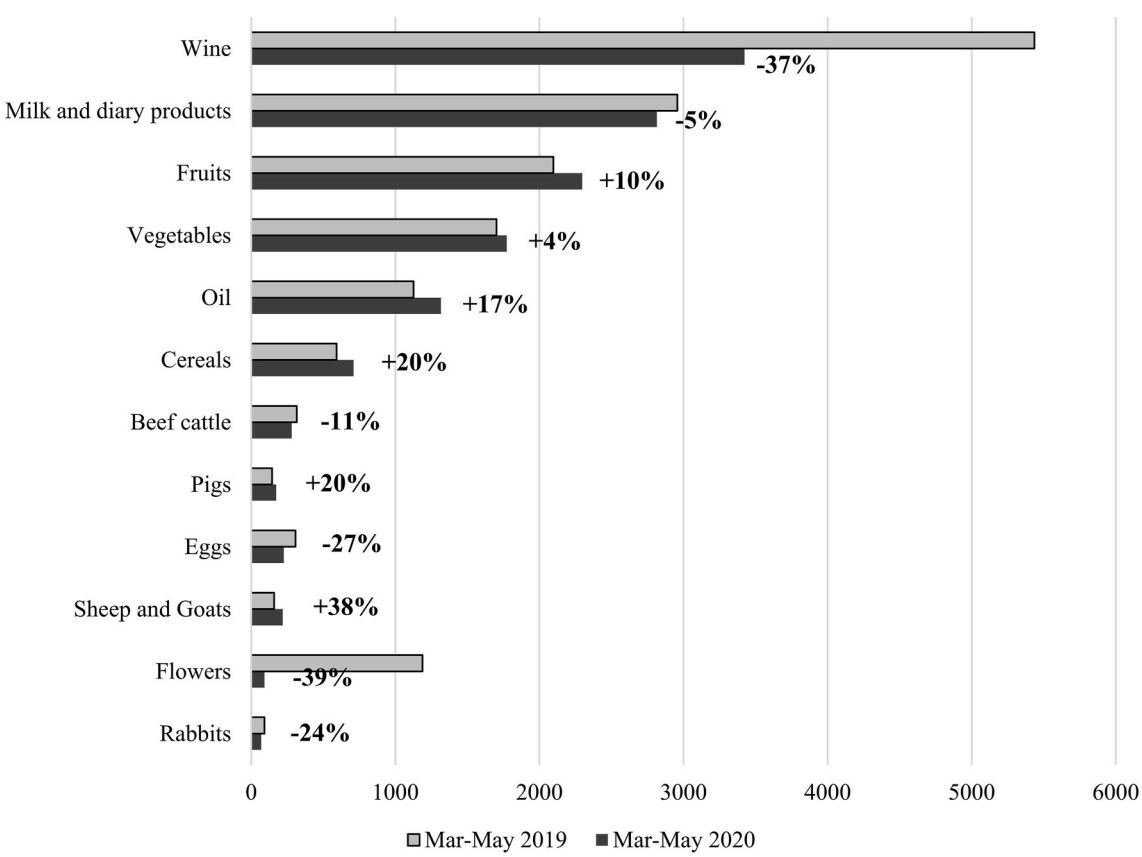

Fig. 6. Value of exports of the main agricultural and food industry products from Italy to the world.

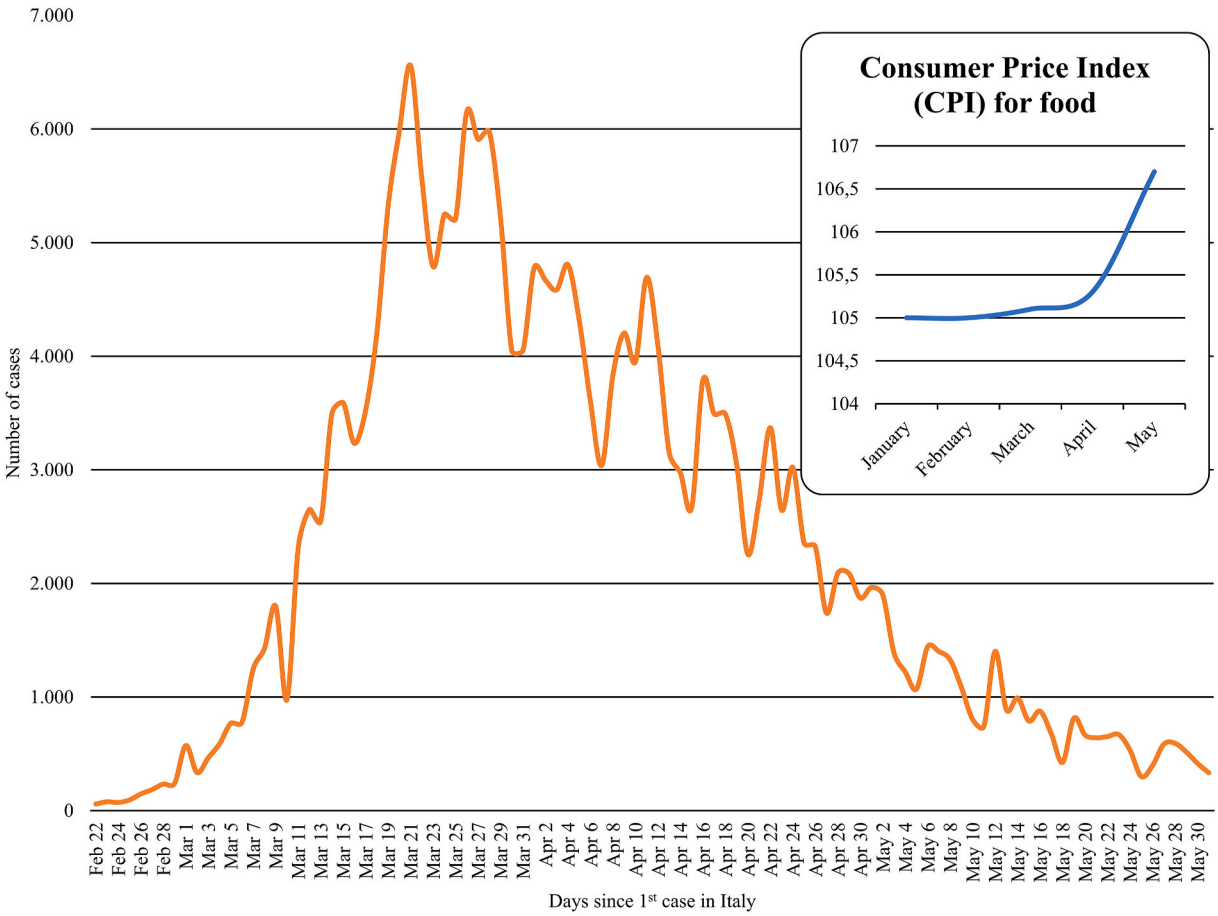

Fig. 7. Italian confirmed cases and Consumer Food Price Index under the effect of COVID-19.

contrary, the lists of livestock products increased compared to the level of the first quarter of 2019 (+3.1%), behind the impulse of eggs, while those of dairy products resume the descent (ISMEA, 2020d). In particular, comparing the data of March, April and May 2020 with those of the previous year, there was an increase of about 8% in the price of cereals, a 42% increase in the price of fruit and an 8% decrease in the price vegetables (Fig. 10). The factors causing such an evident increase in fruit prices during the "first wave phase" (Fig. 1) are many and not all of them can be assimilated to the pandemic. One of the reasons is the anomalous climatic trend, with the alternation of frost and drought, which has upset crops and reduced availability on the markets (Auci & Vignani, 2020, pp. 1–29). Added to this was the lack of foreign seasonal workers in the countryside, who were blocked due to the closure of borders (Cortignani et al., 2020; Haley et al., 2020). A further element is represented by a significant increase in the demand for fruit with a high content of vitamins, recommended by the National Institute of Health, to strengthen the immune system and prevent contagion from COVID-19 (ISMEA, 2020a).

Moreover, an increase in domestic egg consumption of approximately 45% was matched by an increase in prices at the origin of 20%. The same increase was found in many European countries, which were subject to particularly restrictive measures (Akter et al., 2020) and also in the United States the same trend was recorded (Aday & Aday, 2020; Mishra et al., 2020).

On the other hand, the price of milk and dairy products recorded a decrease equal to 10%, compared to the previous year (Fig. 11) (ISMEA, 2020d).

Olive oil was characterized by the most dramatic drop in the Producer Price Index (−37%) (Fig. 12). According to current data, it represents the product that was affected the most by the interruption of exports and the blocking of demand for hotels, restaurants and bars, due to the decree of 11 March (Fig. 1). The effects of the restrictive measures on the olive oil supply chain have affected small and medium-sized companies that do not have commercial relations with the large-scale retail trade and have seen orders canceled by the national Horeca and by the tourism industries. In fact, despite the export growth, the price level is strongly influenced by the negative trend of the domestic market.

On the other hand, the price of wine recorded an increase of approximately 2% compared to the previous year. Despite the negative trend observed in exports and the decline in domestic demand, the wine supply chain was resilient, and the original prices remained essentially stable, especially thanks to the fact that it is a storable product (ISMEA, 2020d).

The prices of olive oil and wine have had opposite trends, despite the harvesting period being in autumn for both products. These differences were determined by the pre-pandemic situations, during which the price of olive oil was in sharp decline, negatively affected by the competition with the Iberian market. The situation worsened with the need to sell off of the stocks created during the closing period of the Horeca channel (Fig. 1). In the case of wine, on the other hand, the positive results achieved in the first two months of 2020 were able to offset the losses recorded in the lockdown period.

Prices in the livestock sector, with the exception of eggs and dairy products, have tended to fall (Fig. 13) (ISMEA, 2020d). The most relevant data concern rabbit and sheep and goat meat, which suffered a price reduction of 21% and 13% respectively. This segment was particularly affected by the drop in demand recorded in the Easter period, celebrated during "Phase 1" (Fig. 1). The closure of the Horeca channel and the impossibility for families to move around for the traditional out-of-town outings during the Easter period had a negative

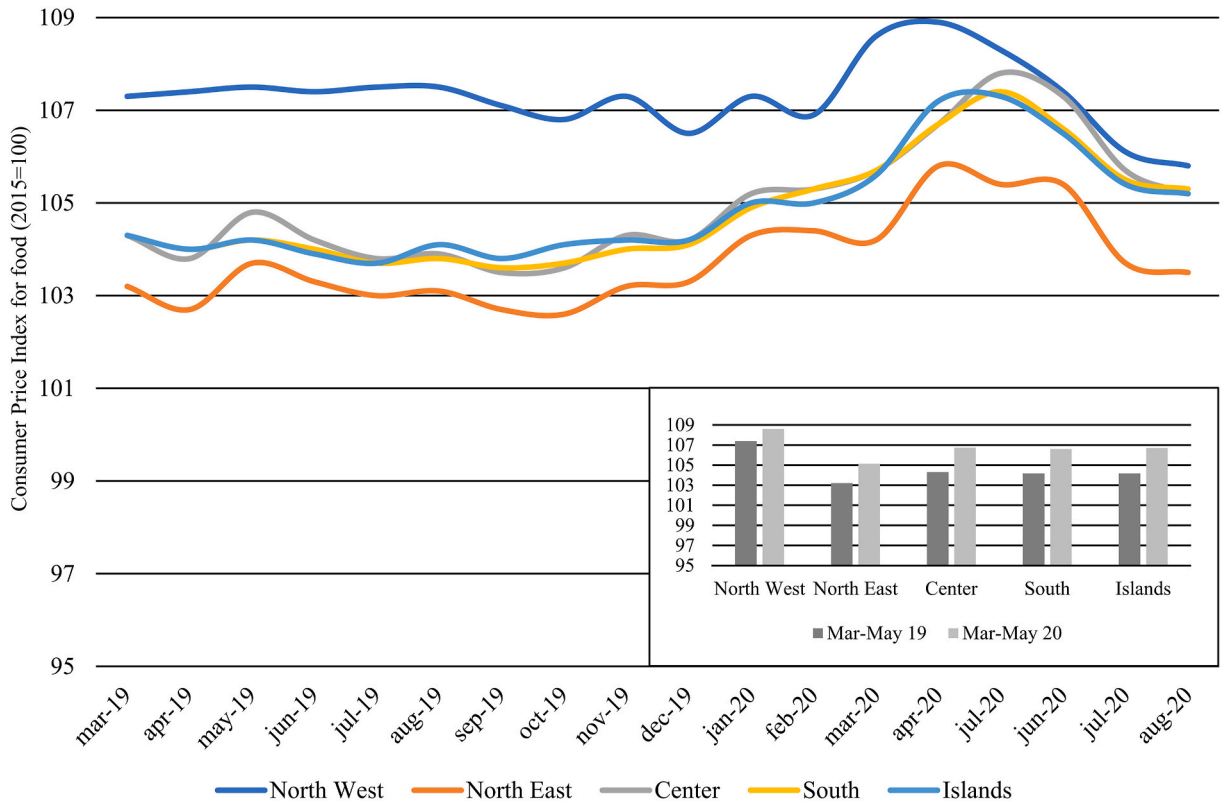

Fig. 8. Trend of Consumer Price Index for food by geographical area and comparison of Mar–May 2020 *vs* Mar–May 2019 (base 2015 = 100).

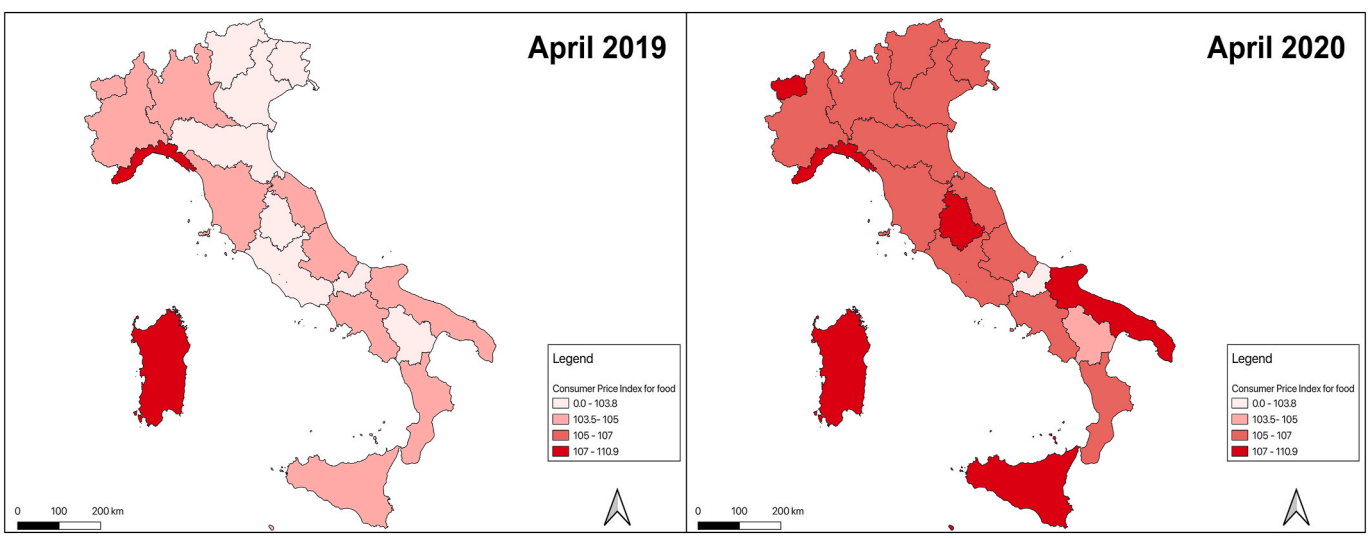

Fig. 9. Geographical distribution of CPI for food in April 2019 and April 2020.

impact on the entire supply chain. On the other hand, beef cattle prices remained stable, while pig prices have been falling continuously since the beginning of the year. The increase in domestic consumption and the simultaneous reduction in beef production have avoided a collapse of prices. However, in the case of pigs, slaughterhouses and ham factories suffered the reduction in the workforce, imposed by the government for the entire duration of the first wave (Fig. 1), and the simultaneous blocking of demand by the restaurants.

3. Effects on the agri-food chain services

Demand shocks have exasperated food supply chains since the onset of COVID-19, exposing its vulnerabilities and raising concerns about resiliency. Much of the disruption to the supply chain appeared to occur at the level of farms, factories and distribution centers; while at the transportation level (roads, rail, air and waterways) there was no evidence of particular slowdowns. In fact, in Italy, even during the most acute phase of the pandemic, the transport and logistics companies continued to ensure their full operations even in the face of substantial losses of approximately 20 billion euros, empty returns and capacity for volumes of goods to be moved halved (ALIS, 2020). In fact, at the beginning of the year, the Italian logistics companies were in a particularly solid state of health with few employee layoffs. Even during the period of the pandemic, they did not make massive use of the social

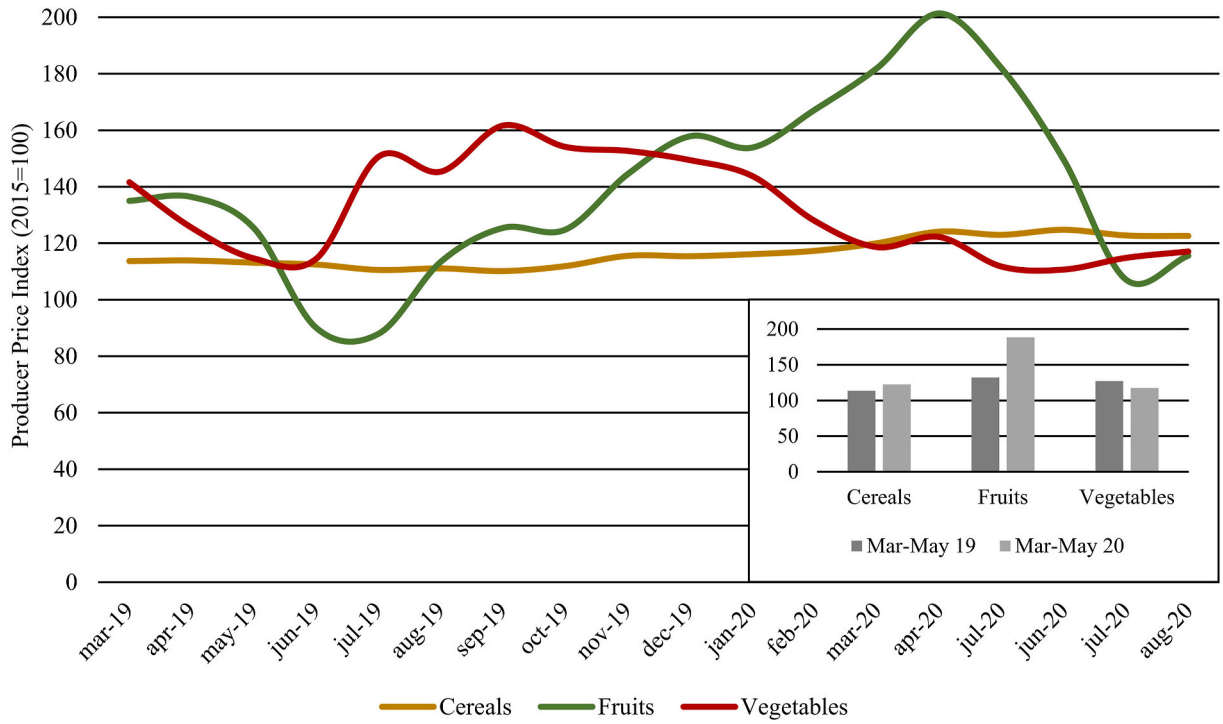

Fig. 10. Producer Price Index trend for cereals, fruits and vegetables and comparison of Mar–May 2020 *vs* Mar–May 2019 (base 2015 = 100).

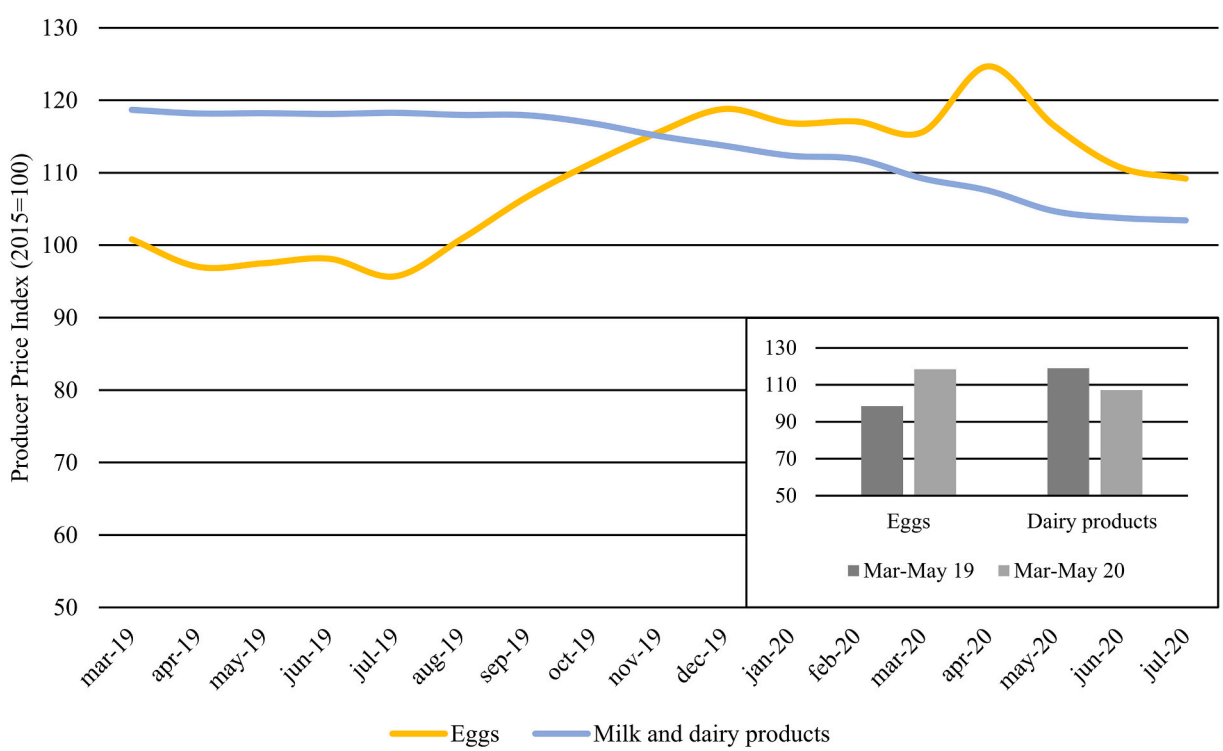

Fig. 11. Producer Price Index trend for milk, dairy products and eggs and comparison of Mar–May 2020 *vs* Mar–May 2019 (base 2015 = 100).

buffer, aiming to preserve their human capital and their workforce, confident that in a few months the volume of traffic could resume the levels prior to the pandemic.

On the contrary, the biggest difficulties were encountered in farms and in factories. In particular, labor shortages caused by workplace absenteeism due to illness (or quarantine, or refusal to work in unsafe conditions) significantly slowed operations and created bottlenecks, particularly in highly concentrated industries such as meatpacking (Maliszewska et al., 2020; OECD, 2020). Further slowdowns were caused by the numerous layoffs and the spread of smart working starting from March. A particularly relevant element concerned the shortage of foreign labor in agriculture, especially in the fruit and vegetable sector, due to the closure of the borders which could not be compensated by Italian workers. The problem of labor in agriculture has affected the

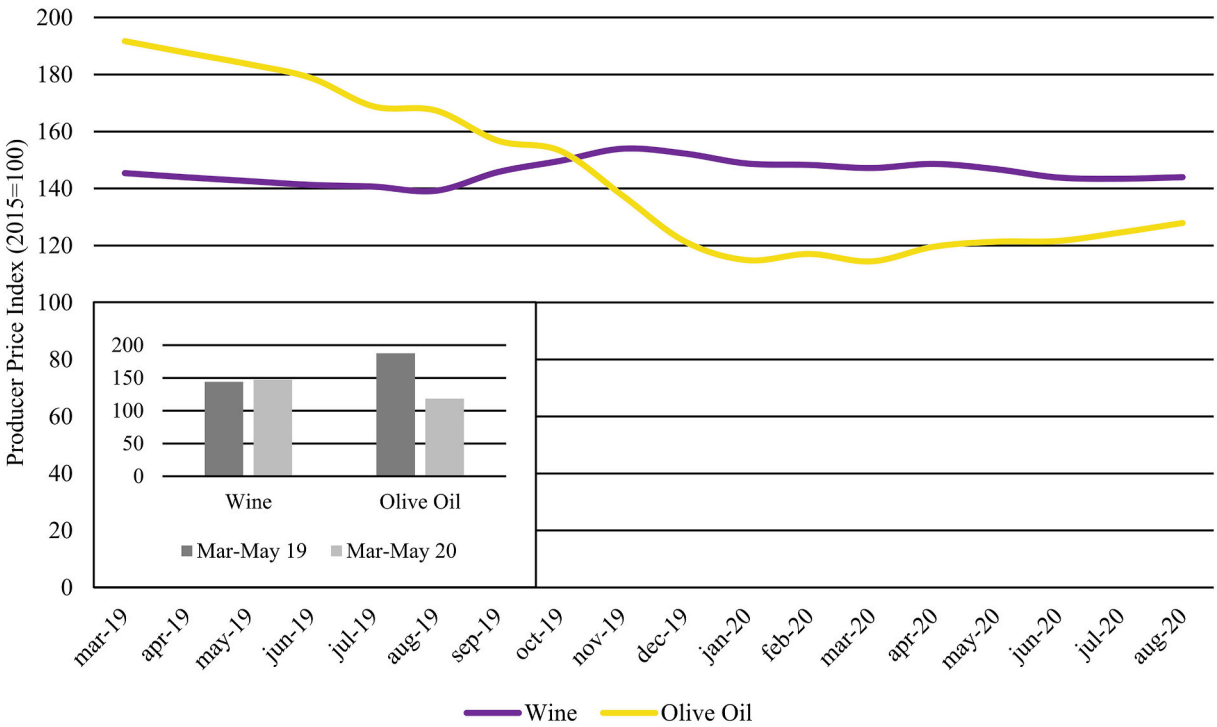

Fig. 12. Producer Price Index trend for wine and olive oil and comparison of Mar–May 2020 *vs* Mar–May 2019 (base 2015 = 100).

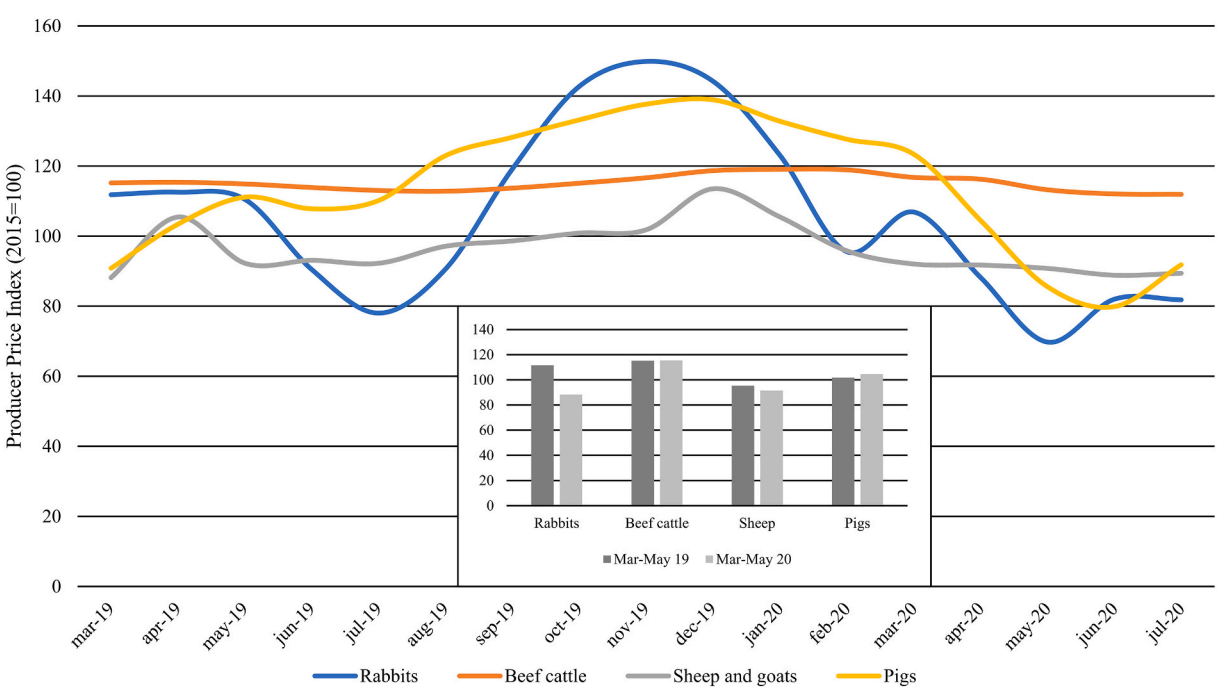

Fig. 13. Producer Price Index trend for beef cattle, sheep and goat, pigs and rabbits and comparison of Mar–May 2020 *vs* Mar–May 2019 (base 2015 = 100).

whole of the European Union where it is estimated that almost one million seasonal workers were missing, with disastrous consequences on crops and with an inevitable spike in the prices of fruit and certain categories of vegetables (COLDIRETTI, 2020). In view of these considerations, the transport and distribution phases of the agri-food chain have been resilient, while the production phase has highlighted some weaknesses. In fact, from the study results, it emerged that the sector of fresh and perishable products, whose production or harvest took place during the COVID-19 first wave suffered effects on the price level, while storable products did not suffer relevant consequences.

4. Long run changes

In addition to the effects of demand-side shocks and potential supply-side disruptions, it is worth considering whether the COVID-19 pandemic will have longer-lasting effects on the nature of food supply chains (Mussell et al., 2020). In Italy, the gradual reopening of activities starting from May 2020 has allowed for a progressive recovery of the

Horeca sector. However, non-domestic consumption will remain at lower levels than those recorded in 2019 due to the decrease in the presence of foreign tourists. To compound this scenario, there could be the impact of the economic crisis on households' spending power (Nicola et al., 2020). In fact, Italy is among the countries in the world most affected by the economic crisis triggered by COVID-19, with a decrease in the number of employees equal to 381 thousand units and a significant increase in inactive ones (+880 thousand units) (ISTAT, 2020c).

Another element that will determine the future of the Italian agri-food sector is the export trend. The scenario appears completely uncertain as the pandemic continues to spread with different timelines in other countries and the measures adopted by governments are different and variable (Gruszczynski, 2020). In general, the impact will continue to be important on companies that depend more on the foreign outlets (fruit and vegetable processing, olive oil, rice, baked goods, pasta, coffee, chocolate, condiments and spices, ready-made meals, wine and sparkling wine).

Finally, in the scenario it is assumed that domestic consumption will remain significantly higher until the end of the year, due to the greater diffusion of smart-working and the prolongation of the state of emergency established by the government until December 31, 2020 (ISMEA, 2020c). However, in a context characterized by anomalous fluctuations in demand, the supply chain could be affected by the Bullwhip effect, triggered by the hoardings of the first months of the pandemic, which will be followed by a period of moderate drop in demand (Metters, 1997). In particular, small fluctuations in downstream demand correspond to amplified swings in upstream demand. Considering the effects of COVID-19 on food supply chains, the spike in demand for some categories of goods affects the correctness of the forecasts of the supply chain actors furthest from the final demand (Zhu & Krikke, 2020). Producers of the goods most in demand during the lockdown, for example, could react by using flexibility tools that increase production to absorb demand and prepare adequate stock levels. The consequences could be an increase in the cost of the units produced, an increase in the frequency and volumes of delivery, with a consequent increase in logistics costs. However, immediately after the hoarding race, there is a real risk of a sudden freezing of the market due to saturation and a decrease in warehouse turnover. In this context, the pandemic has also heightened consumer awareness regarding personal health. Therefore, it is expected that, in the post-pandemic era, there will be a change in the approach to health, with improvements in terms of safety and hygiene. In this regard, the fragility of the agri-food chain can be countered with innovation and technological tools, which, when applied to the agricultural sector and to the food industry, can improve the quality and the efficiency of the production chain (Barba et al., 2018; Deng et al., 2015; Kovačević et al., 2018). New opportunities that include emerging or disruptive innovations in business services and processes could help all actors involved in the food chain to manage their core business for recovery (Rowan & Galanakis, 2020. In addition, in the long term, consumers should be able to make informed decisions about food and the market for health-enhancing food ingredients should rapidly increase (Galanakis et al., 2015). In this direction, according to Galanakis et al. (2018), an efficient approach could be reutilizing healthy food ingredients recovered from food processing by-products, obtaining both qualitative advantages and significant economic savings.

5. Conclusion

Health crises have become numerous over the past few decades. Assessing the impact and effects of these shocks on the supply and value chains is essential to building suitable strategies and thus to achieve resilience. The study of price reactions may serve as a pattern for how to tackle the next pandemic wave or for how to solve other global crises. There is no doubt that the analysis of the COVID-19 impact on the agri-food demand, including exports, can be representative of consumer behavior but also of the whole supply chain reaction and resilience level to the pandemic restrictions. Its implications on logistics and transportation services have been also projected.

Globally, lockdowns are being reintroduced, workplaces are closing again, and those open are not yet back to business as usual. The pandemic stimulated agri-food supply chains to re-consider threats and opportunities, to re-assess priorities and to adapt their systems. This crisis is not likely to remain a one-off. For this reason, further research efforts should be addressed to reflecting on its long-term impacts, such as adverse consequences on job security, supply chains and globalization.

CRediT authorship contribution statement

Benedetta Coluccia: Data curation, Investigation, Formal analysis, Visualization, Writing - original draft, preparation. **Giulio Paolo Agnusdei:** Conceptualization, Methodology, Writing - original draft, preparation, Writing - review & editing. **Pier Paolo Miglietta:** Conceptualization, Supervision, Validation, Writing - review & editing. **Federica De Leo:** Conceptualization, Methodology, Supervision.

Declaration of competing interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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