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Actions and Strategies for Coronavirus to Ensure Supply Chain Resilience: A Systemic Review

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Abstract: The COVID-19 outbreak adversely impacted agri-food supply chains and caused a severe socio-economic crisis worldwide. Preventive measures taken by several countries have affected production and distribution. Moreover, producers have had to face difficulties related to changes in local and international export markets, a decrease in the labor force due to the spread of the virus, and challenges in harvesting, processing, and shipment of products. However, despite the extraordinary nature of the disruption, supply chains have demonstrated a fair, resilient, and sustainable crisis recovery. Although a large number of papers deal with supply chains and the pandemic's impact, a review of measures implemented that comprehensively includes resilience dimensions is still lacking. The scope of this paper is to survey available literature in order to understand whether there are classes of actions and strategies undertaken by meat supply chains in managing the pandemic. Documents were reviewed through a protocol based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) review technique. The survey highlights which actions have enabled supply chain resilience by underling virtuous behaviors and lessons learned. These findings support the need for further investigation of supply chain resilience and offer practitioners guidance toward a greater understanding of impacts and implementable strategies.

Keywords: production; food; logistics; lesson learned; management; coronavirus

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1. Introduction

The agri-food supply chain was among the several supply chains (SCs) that were affected by the COVID-19 pandemic. This is regarded as a premier supplier of commodities. Institutions and governments, therefore, made an effort to ensure its regular operation. The majority of the players in this scene, however, experienced disruptions and slowdowns as a result. The literature emphasizes the fact that labor shortages were discovered at all stages of production, processing, and marketing as a result of seasonal foreign workers' absences from the countryside and industries, particularly those industries with significant human concentrations, e.g., meat industries [1–3].

In the meat SC, this situation resulted in a lack of product availability—ranging from raw materials to final goods—hindered all the more by constraints imposed on the international trade of goods both in import and export [2,4]. Pandemics also generated a widespread reduction in production levels, with production sometimes forcibly suspended or temporarily halted in many facilities [5–7]. An input shortage, either in labor or transportation, generates negative knock-on effects since an input in the SC production process constitutes an output of the previous process [8]. In addition, general government-imposed lockdowns have disrupted the employment of many citizens and consequently led to a general decrease in consumer income [9,10]. Furthermore, the security risk associated with theft and crime seriously threatened retailers [11]. On the consumption side, a visible shock was generated by changes in food behaviors and purchases [12,13]. Points-of-sale also experienced a decrease in end-product availability [14,15]. End-consumer demand has grown

in points-of-sale other than restaurants due to the interruption of HORECA (Hotellerie Restaurant Café) channels. In addition, growing trends in the demand for preservable products and the penalization of highly perishable products emerged [3,16,17], such as consumption frequency change [3,17]. So, the food insecurity phenomenon increased from two main perspectives: on one hand, the perceived lack of necessities for the wealthier countries resulted in irrational and immoderate purchases [18]. On the other hand, a real food shortage occurred in countries where, already before the pandemic, the nutritional level of the population was not fair and adequate [8,19,20]. The persistence of the pandemic may have more permanent consequences on consumer purchasing channels. Consequently, retailers must adapt to this mutation by favoring a multi-channel, physical and online marketing distribution strategy [21]. The pandemic phenomenon significantly impacted all production, processing, retail, distribution, and consumption activities.

According to definitions found in the literature and reported by [22], the pandemic has the potential to cause highly disruptive events that reflect the characteristics of improvisation, destruction, urgency, complexity, and diffusivity, leading to what are known as ripple-effect consequences [23]. Due to the short-time response necessary for the aforementioned reasons, and the difficulty in effectively predicting and preventing such incidents, it is crucial to know how to respond in a concentrated and quick manner. In this case, resilience can avoid and mitigate disruptive consequences on SCs. The ability to respond to the emergency, anticipate possible negative consequences, and learn in the short-term how to behave have been differentiators. The literature shows how some SCs survived by showing good resilience in the face of the pandemic, while others suffered more. The topic remains confusing and has not been systematically investigated. The following study seeks to understand whether there are categories of actions and strategies implemented by the meat SC to respond to or benefit from the pandemic, and which of these have made the meat SC more resilient. Therefore, it is possible to summarize the research questions of the present study as follows:

- RQ1: Do any classes of actions and strategies undertaken by SCs in managing the COVID-19 pandemic emerge in the literature?
- RQ2: Which of these actions and strategies enabled the meat SC to be more resilient during the pandemic disruption?

The paper is organized as follows. Section 2 introduces the topic of agri-food SCs, providing background information from the literature. Specifically, the reasons for a more detailed analysis of the meat SC and its effects with the pandemic are underlined. Section 3 describes the methodology used for the analysis and the systematic approach followed for the review. Section 4 provides an extensive discussion and analysis of the results, i.e., underlying actions and strategies implemented by different meat supply chain actors. Finally, Section 5 concludes and outlines the lessons learned and follow-up research.

2. Conceptual Background

2.1. Agri-Food Supply Chain

The agri-food system plays an important role in man–environment dynamics. This interacts with natural resources (plant and animal), as well as transportation and distribution of finished products to consumers. This system can be analyzed at two levels [23]: (i) a horizontal level, where the functions performed by actors within the system are highlighted; (ii) a vertical level, where the activities performed to arrive at the production of a given product are emphasized. From a vertical analysis comes the concept of a "Supply Chain", which includes all the actors and their interactions that contribute to the production, marketing, and distribution of a good, also referred to as "Farm to Fork" activities [24]. The factors that distinguish an agri-food chain from other SCs are: the type of production, resulting from biological processes that increase variability and risk; the nature of the product, with specific characteristics such as perishability and seasonality; and societal and government attitudes about food safety, animal welfare, and environmental impacts [25]. The literature distinguishes three macro stages in the SC [23]: production, processing, and distribution.

Agricultural production and farming represent the first stages of the SC. In this first stage, agri-food raw materials are produced, derived from the activities of the agriculture, forestry, and fishery sectors [26].

The processing stage distinguishes the agri-food sector and consists of all processing steps of raw materials and semi-finished products, up to the packaging stage. The stages are different for each food product and can be carried out by multiple companies. At this stage, agri-food raw materials are processed through one or more value-added processes [27].

Finished agri-food products are marketed to consumers. Products can be delivered to consumers in two ways: through retail or food service. The retail trade is principally handled by large-scale retail enterprises. Regarding food service, a fundamental SC echelon, a distinction is made between industrial and commercial food service [28]. Industrial catering includes the activities of producing and distributing meals for mass consumption (schools, companies, hospitals, etc.). Commercial catering produces meals for individual customers in the HORECA sector and is characterized by high value-addition.

In addition to the main areas that make up the supply chain, entities that support the activities of agri-food supply chains should be mentioned. Entities that belong to this category are input suppliers; wholesalers; logistics providers; consumers; and institutions.

Input suppliers provide the elements needed for the production stage: goods and services that can be transformed or depleted in production processes. These are, for example, components needed to sustain livestock, grow agricultural products, or additional elements such as energy.

Wholesalers provide the link between the production and distribution stages. Wholesalers purchase agricultural or industrial products for resale to retail entities [29].

Logistics encompasses organizational, strategic, and managerial processes within the SC. Its task is to manage physical and information flows from the production stage to the consumption stage, optimizing activities and responding efficiently to customer demands. The activities performed range from the procurement of raw materials to the preparation of orders and transportation through the distribution network. At different stages, logistics are composed of different specificities due to: the nature of the products, which can be fresh, dry, or frozen; the complexity of the production; the internationalization and geographical distance of markets; and the development of numerous sales channels (e.g., large-scale retail or HORECA) [30].

Consumers represent the final destination of agri-food goods, and therefore the activities carried out by each SC must ensure an adequate level of service for them. In this sense, consumers can influence the choices made by those within the SCs, such as through the preferences expressed in terms of consumption.

Finally, institutions are positioned across the SC, intervening to support it and regulating its activities. These aim to support SCs in carrying out their activities, but they also have the task of monitoring their activities by imposing rules and standards to safeguard end consumers.

2.2. Defining Supply Chain Resilience

A shared definition of resilience is the one proposed by Hollnagel, who states: "A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions" [31]. Nowadays, in a world of constant change, the adaptability of organizations is an indispensable key to success. In [26], the authors define agri-food resilience as the "The collective ability of AgriFood supply chain stakeholders to ensure acceptable, sufficient and stable food supplies, at the required times and locations, via accurate anticipation of disruptions and the use of strategies which delay impact, aid rapid recovery and allow cumulative learning post-disruption." This definition underlines the importance of being adaptive. Agri-food resilience can be ensured if the SC has the ability to detect early signs of change, prepare for the most unexpected consequences, and respond to shock situations quickly and adaptively, being able to transform their operations

to thrive in a "new normal." Through a proactive approach, resilient organizations can turn threats into opportunities, adapting innovative solutions and operating better than their respective competitors.

According to [32], a resilient system must be able to:

- Respond: the ability to know what to do and be capable of responding to regular and irregular changes and opportunities by activating actions or adjusting current operations.
- Monitor: the ability to know what to look for (e.g., indicators) and being able to monitor a system's performance and environment.
- Learn: the ability to know what has happened and be able to learn from experience.
- Anticipate: the ability to know what to expect and being able to anticipate disruptions, opportunities, novel demands, or constraints by observing how factors interact and influence each other.

2.3. Insights into the Meat Supply Chain

For a timelier analysis of the extent to which agribusiness SCs have been resilient to pandemic disruption, it was decided to narrow the scope of analysis to the processes of the meat and dairy product SCs.

The reasons behind this choice are manifold. From a literature perspective, the meat SC has been the most studied during the pandemic period [33]. These SCs, which include both livestock such as poultry, pork, beef, and sheep as well as dairy products, milk, and eggs are believed to be those most directly or indirectly impacted by the COVID-19 pandemic. This is related to the characteristics of such an SC which increase its management complexity.

It is characterized by highly perishable, and many regulated, products that do not allow high flexibility in terms of distribution and timing. Many products are also transported frozen, requiring more sophisticated logistical organization. Moreover, it is characterized by a strong difference between products packaged for large-scale retail trade and HORECA channels. This has made it a model SC because of its need to reconvert processes and plants to shift its production from food service to retail channels during the pandemic disruption. Finally, the presence of indoor, labor-intensive plants has seen the SC face multiple problems related to COVID-19 absenteeism.

Additionally, the importance of meat production in the agri-food sector is generally recognized due to its critical relationship with people, animals, and the environment, as well as the fact that it has a substantial impact on sustainability. Sustainability is commonly considered in terms of three aspects: environmental, social, and economic [34].

From an economic sustainability perspective, the great fluctuation in prices has accentuated differences between countries. Meat prices first rose as a result of COVID-19's effects, since there was less supply and more demand as a result of panic buying. Later, tightening limitations and a decline in consumer spending power led to a major reduction in both meat demand and supply, which in turn led to lower meat prices. On the one hand, high-income countries benefited from the phenomenon and switched to higher-quality cuts. On the other hand, some of the top importing nations temporarily reduced their desire for imports due to logistical challenges and decreased consumer and food-service spending. COVID-19-related market disruptions have reduced incomes in net meat-importing low-income countries, significantly eroding household purchasing power and forcing consumers to replace meat product intake with cheaper alternatives. Next to be mentioned is social sustainability and the complexity of ensuring food safety during a disruption by following and adapting regulations governing traceability and hygiene. Moreover, workers in this SC have been among the most affected by the disease. In fact, COVID-19 transmission and the likelihood of respiratory illness are generally higher for people involved in congestive work atmospheres. Meat and poultry facilities present a congregated work environment that requires special attention to worker safety [35].

From the perspective of environmental sustainability, the SC reports known criticalities related to the rising demand for meat, which has serious implications for global warming as greenhouse gas emissions due to meat production are far higher than for other types of

food [36]. In addition, a critical issue for environmental sustainability is waste disposal and management, which affects almost every stage of the SC. This aspect increased significantly during the pandemic. In particular, the closure of some channels did not allow the sale of several products, which were wasted. In addition, the handling of highly perishable products such as milk on a daily basis, or meat animals that were at the optimal weight for the market, was among the most critical issues for food producers. Industries were forced to throw away many products, invest in reprocessing them where possible, or convert production from fresh to preserved or frozen products.

2.4. Pandemic Disruption

The COVID-19 pandemic was a notable black swan event that had a lasting impact on society, the economy, and public health. During the early phases of the pandemic, food supply networks were susceptible to several exogenous demands and supply shocks as several nations imposed lockdowns to stop the virus' spread. Owing to the temporary shutdown of restaurants and other food service outlets due to lockdown laws, less food was purchased outside of the house. Additionally, these meal expenditures quickly changed from restaurants to supermarkets and other food retail businesses. Short-term stockouts were caused by consumers' irrational buying and hoarding habits, which exacerbated the impact of the shift in food demand to retail shops [28,37].

By looking at the main pandemic effects on agri-food SCs, [38] underlines how these were mainly indirect effects. Indeed, these are effects resulting from the application of containment measures, such as the restrictions imposed on travel, self-isolation measures, social distancing, and the interruption of certain commercial activities, adopted globally to protect people's health.

Other indirect impacts have been related to reduced consumer purchasing power or a decrease in production and distribution capacity [39].

In addition, the impacts presented can in turn be distinguished into short-term impacts, i.e., observed in the first few months after the pandemic outbreak and during the various lockdown periods, and medium- to long-term impacts, which are characterized by high uncertainty and are not yet all identifiable and assessable, since the pandemic cannot yet be considered over.

The COVID-19 outbreak has brought attention to specific echelons and actors in the food supply networks that are vulnerable, but it has also shown how adaptable these systems are overall. The disruption's unusual nature focused emphasis on SC resiliency and short-term instability in intermediate marketplaces.

Overall, when discussing resilience, agri-food SCs have some characteristics [40] that should be taken into account. The biological nature of agricultural production systems brings time dependencies that hinder the ability of these systems to respond to change [33]. This is the case, for instance, for meat forced by weight standards, perishability of products, and storage rules that make it an SC inflexible to changes. In addition, the COVID-19 pandemic has exacerbated existing risks and created new ones for agri-food SCs. Indeed, problems have emerged related to low diffusion of technologies, environmental challenges, resource scarcity, high dependence on global SCs, and issues related to food security [41].

Numerous disruptions occurred at the logistic level, particularly for SCs operating globally [40]. The COVID-19 pandemic affected both upstream and downstream functions in livestock SCs; the disruptions caused primarily affected logistics, which then led to knock-on impacts for other SC agents.

Looking in detail at the meat and dairy SC, it has experienced difficulties at several points in the chain. At the wholesale stage, there were problems related to the distribution of raw materials. In several plants, livestock was suppressed or milk spilled because processing plants or distribution centers could not be reached [38,42].

Generally, meat and dairy products are transported inside refrigerated containers or through air transport, which has been greatly affected by the almost total cancellation of flights [43]. Longer SCs have been affected by logistical disruptions and limited access

to some markets by the initial application of import and export restrictions [38]. In Italy, transport companies continued to provide full operations despite economic losses and reduced capacity [44]. Restrictions on public transport have also greatly reduced access to domestic markets for livestock farmers, particularly in developing countries where road transport is the main mode of transport for agri-food products [45].

On the distribution side, the closure of food service channels [16] has led to a change in demand for certain types of products. These changes have, for example, affected product sizes and packaging features such as labeling, which has been modified to make products suitable for retail sales or package sizes [16]. These adjustments, having repercussions on all other stages of the SCs, have been major short-term challenges for the meat and meat product SCs [40,46]. Such SC echelons have also experienced processing plant closures in the early months due to the spread of the virus within plants [33] and a general lack of manpower and protective equipment [47]. In some cases [39] processing and packaging plant closures, especially for pork and poultry, have led to a halving of operational capacity, further increasing production costs. The propagation of these impacts has thus had knock-on effects along SCs, the so-called 'Ripple Effect' [16], causing shortages for some products and price increases at the distribution stage. In addition, price increases caused by limited access to raw materials understood as labor and packaging materials have also caused problems for consumers, who have been in some cases forced to give up quality food in favor of cheaper food [39].

Concerning retail channels, there have been stock-outs for some agri-food products due to increased demand and logistical problems [46], but also due to consumers' tendency to stock up in a period of uncertainty [47]. Overall, the almost total cancellation of demand from the HORECA channel was offset by the increase in sales volume through retail channels. In fact, there has been a reallocation of food spending [16,48].

Finally, in terms of consumer habits, these have changed radically. Trends such as extra-domestic consumption have been almost totally replaced by takeout and home delivery [49]. There has also been an increase in the preparation and consumption of meals at home [44]. These changes, along with those in foods consumed, are not yet identifiable as momentary or permanent [48]. In addition, this change was affected by the fear of consumers who perceived supermarkets and restaurants as unsafe places, leading them to increase home stocks through the purchase of preserved or frozen products at the expense of highly perishable fresh ones [44].

3. Materials and Methods

The articles and conference papers examined in this evaluation reflect the PRISMA recommendations provided in [50]. There are several review methodologies (e.g., [51]); among them, the authors chose to use PRISMA guidelines as it defines a systematic procedure of study identification, screening, eligibility, and inclusion useful for analyzing a specific topic in detail. The workflow depicted in Figure 1 describes the specific procedure that was followed for this study.

The review is done by searching the Scopus database for articles indexed up to July 9, 2021. Scopus has been utilized in other bibliographic evaluations about resilience, and indexes several reputable publications and conferences [52]. In addition, this database was selected in consideration of its importance to academics. With over 75 million records spread over 27,000 publications and gathered from more than 7000 publishers, Scopus is considered a top source [53]. To gather all publications that widely examine at least one of the issues connected to the food SC and resilience, the search query looks for any article that incorporates topics relevant to the macro areas "Food," "COVID-19 pandemic," and "Supply Chain Resilience." Although the ultimate goal was to analyze the meat SC in more detail, the decision to use a broader inclusion criterion allowed for the inclusion of papers that dealt with specific meat SC traits in the full text but not in the title, abstract, or keywords. The research's focus is only on pieces that were released in English during the pandemic period.

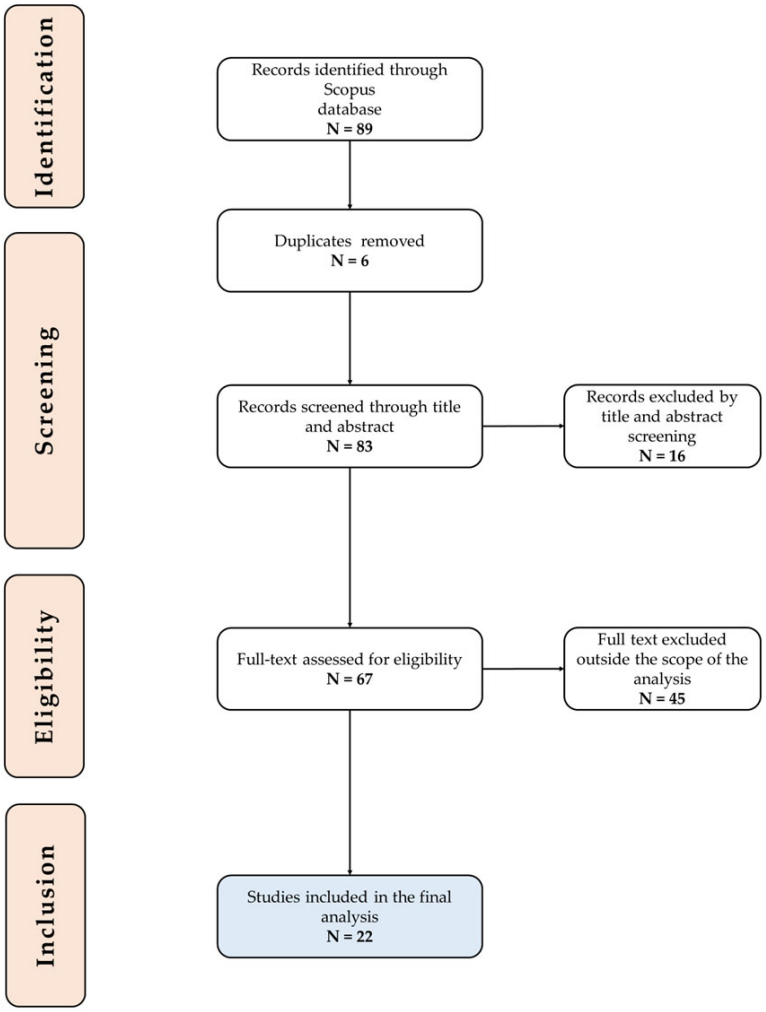

Figure 1. Literature search strategy.

In summary, the search query for the database is:

(TITLE-ABS ("supply chain" AND "resilien *" AND food AND (covid OR pandemic OR "covid-19" OR "2019-ncov" OR "sars-cov-2" OR "epidemic" OR "coronavirus" OR "novel corona virus"))) OR (AUTHKEY ("supply chain" AND "resilien *" AND food AND (covid OR pandemic OR "covid-19" OR "2019-ncov" OR "sars-cov-2" OR "epidemic" OR "coronavirus" OR "novel corona virus"))) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) AND (LIMIT-TO (LANGUAGE, "English")).

The query identified 89 articles, of which 6 duplicate articles were removed. In the screening phase, each article is analyzed in the title, abstract, and keyword to evaluate if its research is coherent to the goal of the review. In this stage 16 records were excluded since their focus was not on a resilience perspective. A total of 67 articles passed through the eligibility phase. Of this, 45 papers were removed after the research team read the full texts and determined that they did not match the requirements for inclusion. These articles did not offer insights on the meat industry and were considered outside the scope of the analysis.

A total of 22 articles are included for further analysis. These documents are reviewed extensively to allow data extraction and synthesize pandemic impacts, actions, and strategies undertaken by SCs to manage disruption.

4. Discussion and Results

The literature review identified from a bottom-up perspective the categories of issues related to RQ1. Specifically, the actions and strategies that were undertaken in the meat SC during the pandemic to respond to the emergency, anticipate pandemic consequences proactively and positively, and help mitigate pandemic-like situations. Overall, seven macro-categories of strategies and actions emerge. Some are further articulated. First, results are reported in aggregate form, i.e., actions and strategies that emerged from the papers. These results are further screened by: Respond, Monitor, Anticipate, and Learn. The aim is to understand when (before/after/during the pandemic) these actions were implemented and what lessons learned emerged from the literature, i.e., improvements to mitigate the negative effects of such disruptions (RQ2).

4.1. Collaboration

The importance of collaboration at different levels within the SC, ranging from a collaboration between countries to collaboration between consumers, is highlighted. Supply chain failure is linked to a lack of collaboration in some cases [48]. This shows the need for system-based thinking [33], assessing the difference (and trade-off) between competitiveness—ability to ensure higher quality and gains at the expense of ideas, skills, and potential that are thus wasted—and collaboration—bringing added value to all actors even though it may be less than the potential of an individual [48]. Supply chains characterized by elevated levels of collaboration and communication had greater adaptive capacity in the face of uncertainty, as well as lower transaction costs. The benefits proved tangible both for SCs where collaborative logic emerged before the pandemic and for SCs that established greater collaboration during the pandemic. Furthermore, it is presented as a future strategy for improvement.

4.1.1. Between Countries

The pandemic revealed how essential cross-country collaboration is to maintaining the operational continuity of agri-food meat SCs. Thus, international collaboration results in the need to maintain active international trade [47]. For some countries, such as those within the European Union, existing agreements facilitated the transport and trade between member states in advance [54]. Thus, in the case of the relationship between the European Union and the United Kingdom and the United States and Canada, respectively, the existence of collaboration between SCs in advance of the pandemic facilitated operations to maintain continuity in the flow of food [40]. The case of China and the United States shows the importance of a collaboration strategy, a lesson for the future to deal with possible uncertainties [55].

4.1.2. Between Competitors

During the pandemic, an unusual collaboration between competitor companies occurred during the pandemic [46], mainly to strategize at the industry level and deal with worst-case scenarios. However, a collaboration between competitors requires mutual trust and willingness to share knowledge and resources. In some sectors, this collaboration has not been possible, as in the case of pork SCs, because of the presence of tensions due to extremely low margins and a near-saturated market. To foster collaboration even in those sectors, government intervention is needed. However, collaboration among competitors helped to respond to the changes imposed by the pandemic in a coordinated way.

4.1.3. Between Manufacturing and Logistic Actors

Among the distinct types of collaborations, this resulted in being the one most implemented. Actors in agribusiness SCs increased collaboration to overcome criticalities. A lesson, especially for major actors, lies in the importance of establishing strong collaborative relationships with smaller actors to foster adaptability [40], despite the asymmetries in market powers that exist in mutual relationships [43]. Moreover, the most powerful actors,

by their influence, can establish guidelines that can benefit all actors in the SC. In France, some large dairies preemptively asked their producers to reduce production by 5 percent to reduce risks and losses along the SC [56]. Companies that invested in having a high level of collaboration and visibility with long-term relationships [42] responded better; in some cases even benefiting, such as by achieving economies of scale through collaborative purchasing [46]. Centralized sales, as seen in Canadian poultry SCs, help in mitigating individual risks since multiple parties share losses. Collaboration in transportation also helps in reducing waste [16]. Plant closures prompted some producers to explore new sales methods and alternative distribution methods, including partnering with restaurants better equipped for door-to-door sales [41].

4.1.4. With Government and Institutions

Concerning the collaboration between institutions and actors within SCs, two points arise: in the short term, collaborative logic becomes essential for the survival of SCs; in the medium–long term, sound policies and strategies to foster the growth and survival of local systems, as well as to implement intervention and regulation policies, are needed [55].

4.1.5. Between Consumers

The presence of actors such as voluntary organizations and food banks who generated support for end consumers via spontaneous initiatives was key during the pandemic. At a local level where, following the closure of schools—the sole source of healthy food for poor children—the consumers' initiatives can convert school-meals back to products deliverable to the homes directly [48]. Moreover, collective actions facilitate exchange between end customers and food banks [43,54]. Local support networks, along with public interventions and voluntary organizations, were effective support for consumers. The success of locally rooted communities also shows the importance of reinforcing neighborly relationships between cities and surrounding places to increase the capacity to respond to shocks. Importantly, these initiatives often started without real institutional support [48].

4.2. Flexibility

Supply chains over the years underestimated the possibility of a pandemic-like event, and thus, the value of flexibility [55]. Among the more economically developed countries, flexibility appeared simpler to pursue, both in terms of time and cost. Although many of these SCs continued to operate according to pre-existing logic, such as Just-in-Time logic, they still demonstrated flexibility in quickly and efficiently reorganizing production around a more basic product mix [43,56]. Flexibility, while decreasing the optimal price, improves resilience, and this can greatly benefit a system operating in an uncertain and turbulent environment [46]. In the future, evaluating investments in flexibility with alternatives in supply sources and distribution networks during normal periods is expected to become a top priority. This increases resilience when future disruptive events, believed to be increasingly likely, occur [40]. Especially for the meat sector, a trade-off between an efficient system that offers affordable prices during normal times [44] and flexibility must be evaluated. The latter, although helpful in extraordinary situations, leads to an increase in costs—e.g., related to an increase in delivery frequency and volume—and, consequently, an increase in total logistical expenses [33]. During the pandemic, some SCs or individual companies were flexible in adapting and finding new markets and distribution channels, stopping production which was deemed not useful [46]. Thus, a key theme emerges: in modern SCs, there is a widespread lack of flexibility, mainly linked to the resulting decrease in efficiency and, thus, to increased costs. However, targeted efforts should find the right balance in the future.

4.2.1. Flexibility in Productive and Warehouse Capacity

Manufacturers, packaging plants, and distributors required several steps to adapt to flexibility needs. Some measures increase the production capacity. As an example,

actors may increase working hours, hiring of additional staff [43], or production—before closures—to prepare for the foreseeable increase in demand across retail channels [42]. Regarding warehousing, whenever possible, overstocked products exploited internal or external capacity, for a fee, to prepare in advance for new closures. Where increased storage failed to be feasible, products were sold at lower prices or donated to charities [46]. Increased inventories due to declines in demand for some livestock products led to higher costs for cold storage with reduced margins, which were already significantly impacted [54]. Massive intervention on storage failed in some cases, e.g., for fresh and highly perishable products [55].

4.2.2. Product Flexibility

As the food consumption of end-customers changed, different products experienced vertical drops in demand. One of the main measures consisted of reducing the variety of products to focus exclusively on the most popular ones [43]. Another strategy was converting products into storable and higher-value-added ones, hoping for increased sales later [16,45]. As a result, more processed and storable goods with a longer shelf life were manufactured [57].

4.2.3. Flexibility in Supply Channels

Some actors experiencing an interruption of supply channels reacted through self-production or stockpiled inventories for the short term. The latter happened especially for producers with supply channels in China, since trade with that major exporter of production inputs was suspended in several scenarios [55]. Other solutions involved the search for alternative supplies, mostly local [43].

4.2.4. Flexibility in Sales Channels

During the pandemic, the most needed flexibility was the distribution channel related, without losing operations continuity [16]. Some producers, after losing the restaurant channel, switched to the retail or home sales channel [40,41,48] without transitioning via wholesalers [48]. As an example, in the United States, in the turkey meat SC, a product traditionally targeted to restaurants and with a high profit margin, producers exploited retail channels despite lower, and sometimes negative, margins [42]. Locally based systems were advantaged in finding new sales channels and end consumers because of strong personal relationships and trust. In contrast, other systems, due to a lack of skills and relationships, failed to develop such relationships and thus lost customers and revenue [33]. Restaurants responded by implementing or strengthening takeaway and home delivery services. Some tried to offer alternative services, such as at-home meal preparation kits [43]. Among alternative channels, thanks to government subsidies, some players deliver products to food banks [38,42]. For actors operating in global and highly efficient SCs, an upstream problem arises where significant differences between products in terms of the type of good and channel of reference led to difficulty in switching between distribution channels [42]. Here, too, there was a call for increased flexibility, possible with innovation and investment in technology. In the study by [55], the centrality of flexible distribution channels is emphasized, i.e., being equipped to serve food service but also retail, so that when disruptive events occur, organizations can switch from one channel to the other with sustainable costs and in a short time. Flexibility is an opportunity when operating in an uncertain environment. Of course, interoperability, e.g., between distribution channels, has no highly discernible value under normal conditions, but when some channels are completely interrupted, it represents an added value for businesses. Some features facilitate interoperability, such as the consolidation of good relationships, the presence of warehouses with ready-made packaging materials for different channels, and transport vehicles. In this way, a potential failure can become an opportunity, without depending entirely on government interventions and support.

4.3. Government Interventions

An important lesson from the pandemic lies in the relevance and centeredness of global, national, and local institutions. Especially in mitigating the short-term effects, institutional interventions are essential. Although much of the impacts on SCs resulted from the restrictive measures applied by institutions to protect human health, efforts to limit as much as possible the resulting economic damage emerged. The influence of states in regulation is a primary consideration [47]. They achieved the goal of facilitating the production and circulation of essential products, although sometimes a lack of timely action [47], and coordination between governments arose [48]. Especially when the pandemic's magnitude was not yet foreseeable, governments recommended operating to respond in advance to the possible impacts [43]. Additionally, they ensured international trade and open borders for the operations of essential goods [33]. At the continental level, for example, the European Union mandated the opening of 'Green Lines' [46] for border crossings by vehicles transporting food, and defined which categories of workers were considered critical, ensuring their movement [49]. In addition, in the United States, the president took several actions to ensure the continuity of meat operations [39]. From an economic perspective, however, for the European Union at least, a lack of adequate funds for individual governments emerged [49]. The European Union had insufficient resources to support interventions for all member countries. At the country level, policy responses kept borders open but also facilitated retailing [54,57]. In the future, the support of national institutions in promoting short and local SCs, including through consumer awareness, becomes necessary to increase self-sufficiency and reduce dependence on international trade [39]. Furthermore, governments can apply strategies to promote certain products, whose consumption should be increased during times of crisis, to facilitate the work of SCs [55].

4.3.1. Subsidies and Support

A widely applied measure by individual country governments was to provide funds and subsidies. Another central measure was to offer the possibility of purchasing unsold products at a reduced price for distribution to organizations that support people most in need [54]. For instance, governments flowed surplus production to food banks. In Catalonia, EUR 4 million was provided for purchasing products from small farmers to supply food banks to help both small producers and consumers [38]. To the total closure of the restaurant channel, governments responded through programs to halt layoffs and by providing subsidies to financially assist not only restaurant employees but also owners [58]. In some cases, governments allocated funds to enable meat producers to access facilities for private storage [46].

4.3.2. Policy Relaxations

After applying restrictive measures, governments emanated several policy relaxations [43] to limit the negative impact on the flow of food products. As an example, executive orders were made to ensure the continuity of operations in poultry and livestock processing and packing plants [45]. The U.S. Food Safety Inspection Service temporarily granted the ability to increase throughput within cattle, pork, and poultry processing and packaging plants. The Food and Drug Administration granted temporary exemptions from certain safety standards to facilitate the switching of products from food service to retail channels [33], encouraging format conversion [42]. However, certain relaxations effective in the short term can cause future problems of a different nature, such as loss of consumer loyalty or food security issues.

4.3.3. Import/Export

Some European Union member countries imposed export and import prohibitions to ensure the sufficiency of food, or to protect local producers from foreign competition in an already hard time [57]. These measures, thanks to institutional efforts (e.g., the European Union and World Trade Organization), were short-lived and limited in their

impact. Thereafter, import/export logic ensured the ongoing availability of food, ensuring the openness of the international market and allowing firms to access new sources of supply or new sales channels if existing ones were compromised [43,54].

4.4. Technological Innovation

Technological innovation proved necessary to facilitate production activities and transactions along SCs [33]. Besides sales channels, innovation proved necessary also at the production level, notwithstanding the difficulty of adapting rationale for different food goods and coordinating activities within SCs and with external actors. During the pandemic, communication technologies facilitated information exchange, transportation, and the creation of new business models [54]. Potential long-term changes may include an increase in automation, e.g., the use of robotics for logistics, quality control, and packaging tasks, and digitization, e.g., for verification of export certifications and other requirements, optimizing logistics, and deliveries. Investments in upgrading infrastructure for online delivery services may permanently alter the retail landscape [40].

4.4.1. Automation and Robotics

In well-developed countries, a strong and further boost to automation emerged [48]. Accelerating automation processes at various stages of SCs in the future is necessary. For example, the use of robots in plants can offer great potential for safe production and for increasing the workforce, and thus, production levels [16]. A significant problem regarding the use of robotics in meat SCs relates to the high degree of product and process differentiation for many of the processing and packaging activities. As a result, to date, these are manual and people-based activities.

4.4.2. Digitization for Visibility and New Sales Channels

Manufacturers and distributors used digital solutions to explore or strengthen alternative sales channels when traditional ones were closed. In response to the effects of the pandemic, alternative sales and delivery methods were explored [43], such as e-commerce and online delivery [38]. The ability to sell food through online platforms helped small producers in shortening the distance to the final consumer [16]. However, not all small businesses were able to take advantage of this opportunity. They were unprepared [40], with a risk of further losses in the future [45]. Digital platforms were also useful to aggregate a large number of producers and connect them to new customers [54]. In terms of visibility, when uncertainty is high, digital solutions help institutions that operate in global SCs. For example, Australian institutions developed a system for transmitting information about meat products for export to facilitate regulatory authorities in verifying the authenticity and traceability of products [33].

4.5. Diversification

Diversification of markets, customers, and sales channels was among the most popular responses [54]. Diversification can be seen as a good measure—more easily applicable before a shock event—to increase resilience and better cope with adverse events, even at the expense of the also-attainable economies of scale and consequent economic gains [48,49]. In adaptation, a major problem is the timing and amount of investment required. Each point of differentiation along an SC involves rather high and especially irreversible fixed costs, with no certainty of an economic return on investment [16]. Only few SCs were able to anticipate events by diversifying [57]. Subsequently to the near-total closure of the restaurant channel, firms were proportionally impacted according to their ratio of market share from restaurant channels to retail. The more the specialization in the restaurant sector, the more the organization was negatively impacted. There is similarity concerning the balance between domestic and global market shares. The momentary closure of borders has locked in, or at least reduced, markets across and beyond the European Union. This resulted in a downturn in export demands for many countries. Again, firms were impacted

proportionally according to the ratio of market share from domestic sales to market share from export sales [46].

4.5.1. Supply Diversification

Diversification emerged at the supply network level. The presence of local alternatives, even if more costly, should be considered in the face of global disruptions. Diversification toward locally produced inputs was a way to cope with transportation and import disruptions [54].

4.5.2. Product Diversification

A wider range of goods may help when demand for certain products is reduced or eliminated. This occurred for the most prestigious meat products [47].

4.5.3. Transportation Diversification

Transport diversification is often more difficult. For certain fresh and highly perishable types of meat, numerous transport constraints related to their nature arise. It is simpler to diversify for products not requiring special atmospheric, environmental, microclimate, and speed-of-movement conditions; for example, processed products with a long shelf life, such as canned products [43].

4.5.4. Market and Sale Channel Diversification

The pandemic has shown the importance of diversification of sales networks. For domestic and export sales, the same considerations made for procurement remain. Focusing on export may lower resilience in the presence of global-scale disruptive events, while basing decisions on the domestic market may cause difficulties in terms of competitiveness. Even at the restaurant and retail level, a balance is required: the specialization to exclusively one channel, i.e., restaurant, proved problematic. For example, in the United States, half of food expenditure is non-domestic consumption, and those who exclusively supplied the restaurant channel were severely affected when unable to adapt to supply other channels [47]. Changing the sales mode was also critical because of the diversity inherent to the channels, considering, for example, on-site consumption or take-out. In terms of diversification, the issue of wholesalers is again crucial. For producers, supplying wholesalers can bring advantages, especially in uncertain times, because of the risk-sharing. However, exclusive dependence can lead to problems. [59] show that issues emerged for three types of producers, distinguished according to the sales channels they used: producers supplying wholesalers exclusively, producers supplying both wholesalers and alternative sales channels, and producers supplying alternative sales channels exclusively. It turned out that those who sold exclusively to wholesalers were the most affected. The greater the diversification, the lower the negative impact.

4.6. Localization

Lengthy and global SCs have been significantly affected; yet, the generalization of impacts and responses should be avoided, since agri-food systems are characterized by not only common peculiarities but also many differences [38]. Under severe constraints in certain contexts, the need to reduce dependence on global systems by promoting local systems emerged. Thus, some national governments carried out actions to support domestic production and encourage consumers to buy local products, such as in Bulgaria [49]. Global systems were affected more by the limitations on mobility, because of the absence of the labor force, limited movement of goods, and contagion of workers. Moreover, more exposure to risk is perceived, as they are dependent on the operation of international transportation. On the other hand, local systems suffered from the closure of local markets and the restaurant channel, as well as the lack of skills and logistics to implement alternative forms of sales, such as e-commerce. Small-scale local systems, with higher costs for less efficiency, may also result in higher prices while still maintaining a high degree

of vulnerability, especially for unexpected events [40]. A trade-off between vulnerability to international trade disruption and shocks at the local level is, then, an issue [49]. Short SCs, with supply from local entities and strong people-to-people relationships, can provide greater resilience in times of uncertainty than international trade, which is more susceptible [48]. They can also give more confidence to consumers by providing quality and affordable food [41]. Local systems lacked flexibility in moving toward alternative sales and transportation channels as well as customers [33,40,43]. These SCs are economically less efficient, lack economies of scale, and thus generate a higher price due to exogenous shocks in demand and supply [40]. A further problem concerns the informal nature of most local activities [45]. Breeders and small-scale producers have no access to banks or government subsidies provided during the emergency. Overall, short, local, and independent systems were strongly impacted, both positively and negatively [54,56]. Some systems reorganized quickly through adaptability. They developed new, even shorter, sales channels by strengthening local interdependence with other producers. This solution offered a wider range of products to consumers in a single outlet and increased connectivity with consumers who favored local products. Others, focused on direct sales, for example to restaurants, faced few options to adapt because of market saturation or their inability to refocus a highly specialized business [46]. Rarely, the removal of intermediaries along SCs was seen as possible [54]. Others, however, benefited from border disruptions as declining imports reduced competition. Sometimes, the weakness of complex, distributed SCs was stressed [48]. Transportation and distribution represent potential vulnerabilities in SCs that cover wide geographic distances and cross-national borders. Each problem along trade borders leads to a significant increase in costs, and a consequent reduction in competitiveness [40]. Logistically, global SCs are being affected by interruptions and limited access to markets [38]. The impact on declining exports is likely to come again in the future for those who continue to depend excessively on foreign sales channels [44]. Companies with a large export share have repeatedly expected situations of uncertainty in a continuously changing environment [46].

4.7. Vertical Integration

A concentrated system with few large firms—compared to one with many small, dispersed firms that serve local markets—can create bottlenecks in SCs at times of shock, with failure at some points causing disruptions throughout the system [33,40]. For example, outbreaks in large meat processing and packaging plants, resulting in closure or reduced capacity, caused both upstream and downstream impacts. Systems that integrated small- and medium-sized enterprises with larger ones were more resilient than those dependent only on a few large players [57]. There is recognition, by policymakers and big players in SCs, that the revaluation of 'supply chains in the middle' has become essential. In China, there is a huge gap between large industries and local initiatives. Here, to invest in small producers, leading them to grow and integrate so as to also reduce the countries' dependence on the global economy is required [55]. The presence of minor subjects around larger and more integrated ones should also be reinforced.

After defining the categories of actions and strategies, each paper was further analyzed, as mentioned before. Concerning the four dimensions of resilience researched, the Monitor dimension is missing. This is because the pandemic was a highly disruptive event, i.e., fast-moving, sudden, and unpredictable. Consequently, it was not feasible to implement monitoring actions and strategies. The seven macro-categories of actions and strategies identified and discussed from a resilience perspective are summarized in Table 1.

Table 1. How the authors address the 7 macro-categories of actions and strategy in a resilience perspective.

	Resilience Dimension			Actions and Strategies						
	Respond	Anticipate	Learn	Collaboration	Flexibility	Government Interventions	Technological Innovation	Diversification	Localization	Vertical Integration
[54]	x			x	x	x				
	x			x		x		x		
[42]		x		x						
			x	x	x		x			
[45]	x			x		x				
[58]	x					x			x	
			x				x			
[49]	x					x				
[38]	x				x	x	x			
			x	x	x		x	x		
[43]	x				x	x	x	x		
		x		x			x			
[47]	x					x				
[40]	x			x	x		x	x		
		x							x	
[48]	x						x		x	
			x	x			x			
	x			x			x		x	
[16]		x								x
			x							x
[39]		x		x						
			x	x		x				
[33]		x		x	x		x	x		
[46]		x			x			x	x	
[44]			x		x		x	x		
[60]			x	x		x		x		
[57]			x	x	x	x	x	x		

Moreover, the extensive analysis conducted for RQ1 indicates how these SCs have responded to, anticipated, and learned from the COVID-19 disruptions. The results are shown in Table 2.

Table 2. How did the meat SC respond to, anticipate, or learn from COVID-19?

What Enabled a Positive Response to the Pandemic?	What Current Features Enabled Positive Anticipation of the Pandemic?	Which Are the Main Lessons Learned from the Pandemic?
Coordinated systems [16,41,46,54]	Non-overly vertical integration [16,33,40,46]	The overly vertical integration disinhibits adaptability in face of disturbance [16]
Network between farmers and consumers [16,40,42,45,48,54]	Farmer–producer cooperation [33,39,42,43]	The industries with more collaboration fare better [38,42,57,60]
Solid organizations [16,48,58]	Buyer–seller collaboration [33,39,42,43]	Collaboration within SC partners mitigates negative effects on price and demand [38,39,42,57,60]
Risk-mitigation strategies for packers and producers [42,45]	Local and personal relationships [33,39]	Although cooperation exists, in times of crisis cooperation between industry players should be promoted by providing slaughterhouse functions, stimulating sales, and creating higher value-added products [38]
Flexibility of local and regional systems [38,40,42,43,54]	Automation in production [43]	The activation of multi-faceted social safety nets is needed [48,57]
Interpersonal relationships [40]	Blockchain [43]	The promotion of short food chains and local products should be supported at the national level [39,57,60]
Communication with consumers [38,43]	Visibility on stock levels [43]	The difficulties in accessing inputs and financing must be avoided by governments [39,57]
Modulation of production levels [38,42]	Foreign labor over-dependence [40,46]	ICT to facilitate information, transaction, and new business models are needed (e.g., sharing of information to prevent sharing of a fraction of orders fulfilled) [44,48]

Table 2. *Cont.*

What Enabled a Positive Response to the Pandemic?	What Current Features Enabled Positive Anticipation of the Pandemic?	Which Are the Main Lessons Learned from the Pandemic?
Increasing operating hours, hiring additional employees [58]	Customers' and products' diversification [33,46]	Improvements in terms of safety and hygiene innovation, and technological tools, improve the quality and the efficiency of the SCs [42,44,57,58]
Delivery services [40]	Distribution channels' diversification [33,46]	Consumers should be able to make informed decisions about food and the market for health-enhancing food ingredients [57,58]
Contactless transactions and digital payments [40]	Suppliers' diversification [33,46]	Particularly in highly concentrated industries (e.g., meatpacking) labor automation is needed [42]
Online shopping [38,40]		Investment in technologies to switch sectors more easily (e.g., shifts between the food service and retail sectors) [38,42,44,48]
Robotics, automation, and intelligent machines [16,38,40]		Domestic consumption will remain significantly higher until the end of the pandemic, due to the greater diffusion of smart-working [38]
Alternative suppliers [43]		Consolidation of e-commerce, home cooking, and local food [42,48,57]
Local suppliers [16,42,45]		
Government intervention for mobility [42,43,47,49,58]		
Government intervention for cash transfer and financial aid [43,47,49,58]		
Government intervention for food distribution [38,43,45,47,49]		
Government intervention for workers' regularization [43,47,49,58]		
Government rules (e.g., DPIs)[40,45,47,49]		

5. Conclusions and Further Developments

The analysis investigated the literature regarding the impacts of the pandemic on agri-food chains of meat and its derivatives. It identified and assessed in terms of resilience the key issues, characteristics, or actions that made SCs more resilient. It also showed the lessons learned by the actors involved to be helpful for the short term but necessary for the long run. The centrality of flexibility, especially in reactive terms, emerged. As the number of viable distribution channels decreased, flexibility mitigated the negative effects. In terms of capacity, either of production or a warehouse, for upstream production stages: those who level production and expand storage activities were less affected by pandemic, notably in the short term. Flexibility in channels—both supply and sales, where networks were established earlier—and the ability to find alternatives were also key. The need to create collaboration also arises. Regarding collaboration between countries, coordination and information exchange in the first months of the pandemic to apply homogeneous measures protected the flow of goods on a global scale. For consumers and associations, collaboration helped in matching and balancing supply and demand. Institutions regulated activities, and the importance they will have once the pandemic is over to support SCs at the strengthening level is quite evident. Other insights included the importance of technological innovation. This has been crucial for downstream actors in researching and creating new sales channels; it also helped internal controls within SCs and between countries in the export field. Regarding the geographic scale and complexity of SCs, conflicting views exist but lessons are available. Operating on a global scale can yield economic advantages. However, the pandemic highlighted the need for local alternatives.

On the other hand, exclusive reliance on the local market can increase vulnerability to other events. About complexity, it should be important to increase integration between small and large actors through collaboration. Large subjects, due to their high efficiency and power, gain advantages, but the high distance of smaller subjects can be a problem. The latter manages a lack of economic and technical resources thanks to strong relationships between themselves and consumers. An interesting point is that, despite the imbalance in their powers, achieving greater integration of these two figures might benefit all SCs. The overly vertical SC integration disinhibits adaptability in the face of disturbances. A too-concentrated system creates bottlenecks at times of shock, with failure at different points causing disruptions throughout the system. A further important lesson from the pandemic lies in the relevance and centeredness of global, national, and local institutions. In mitigating both the short and long-term effects, institutional interventions are essential.

Finally, as with all research, this work has some limitations, which offer opportunities for future research directions. Despite the analysis focusing on the meat SC, the authors consider the insights obtained an important step for more extensive analysis with new areas involved in the agri-food SC. Future steps should broaden the analysis to include other sectors of the agri-food SC so that a complete view of all actions and strategies undertaken can be obtained. In addition, a qualitative approach was chosen for this analysis, reporting a bibliometric analysis and highlighting descriptive findings that were analyzed from a resilience perspective. In this regard, this work would serve as a tool for all practitioners to guide organizations toward a greater understanding of disruption impacts and implementable actions and strategies. Finally, future steps should introduce a quantitative approach to investigate the possible correlation between echelons' characteristics, implemented strategies, and resilience dimensions that can guide the practitioner in forecasting scenarios and choosing investments.

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