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Performance of the Food Value Chain Network in Turbulent Scenarios: COVID-19 and food Scandals*

Funcionamiento de la red de cadenas alimentarias en escenarios turbulentos: COVID-19 y escándalos alimentarios

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Abstract:

Objective: The present work analyzes the Network of Food Chains (NFC) subjected to turbulence that forces the design of strategies to meet the objectives of supplying humanity with quality affordable food in adequate quantity and times.
Materials and Methods: The methodology examines the impacts of the NFC through its flows of production and services, financing and information, according to the paradigm of industrial organization structure-conduct-performance. The main impacts on structure and behavior and the consequences on their functioning are described.
Strength and resilience are important strategies that guide the Spanish Agency for Food Safety and Nutrition (AESAN), which has a special role in coordination with the European Food Safety Agency (EFSA) and other public and private institutions.
Results and Discussion: The results of the present study include an analysis of the health and economic impacts. The effects of paradigm shift, risks and challenges faced are summarized in a SWOT matrix. In the case of Spain, the effects of African swine fever, rapeseed oil scandals, mad cow disease (BSE) and COVID-19 are reported.
Conclusions: Finally, the conclusions show the basic principles that NFC analysis models must follow, as well as the strategies to strengthen resilience to disruptions.
Keywords: Food Chain, Resilience, Pandemic.

Resumen:

Objetivo: el trabajo analiza la red de cadenas alimentarias (RCA) sometida a turbulencias que obligan a diseñar estrategias para cumplir los objetivos de abastecer a la humanidad con alimentos asequibles, en cantidad, calidad, lugar y tiempos adecuados.
Materiales y métodos: la metodología plantea los impactos en la RCA a través de sus flujos producción y servicios, financiación e información, según el paradigma de organización industrial estructura-conducta-funcionamiento. Se describen los principales impactos en la estructura y la conducta, así como las consecuencias en su funcionamiento
En estrategias esenciales se incluyen la fortaleza y la resiliencia, el papel de la Agencia Española de Seguridad Alimentaria y Nutrición (AESAN), en coordinación con la Agencia Europea de Seguridad Alimentaria (EFSA) y otras instituciones públicas y privadas.
Resultados y discusión: los resultados incluyen los efectos sanitarios y económicos. A través de la matriz DAFO se exponen los efectos de cambio de paradigma, riesgos y retos afrontados. En el caso de España se informa de los efectos de la peste porcina africana, los escándalos del aceite de colza, las vacas locas (BSE) y el COVID-19.
Conclusiones: finalmente, las conclusiones muestran los principios básicos que deben seguir los modelos de análisis de las RCA, así como las estrategias a seguir en el fortalecimiento y la resiliencia ante los impactos recibidos.
Palabras clave: cadena alimentaria, resiliencia, pandemia.

Author notes

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Introduction

The Food Value Chain Network (FVCN) is subject to changes that impact its performance and force it to remodel itself to continue fulfilling its objectives within a sustainable development framework. The goal is to provide a series of products and services through flows that include the movement of products to consumers, their financing, and the information generated and received by the actors involved.

Turbulent scenarios that impact the FVCN may be brought about either by internal or external factors. Internal factors include a lack of coordination and stakeholder management and inadequate control of the quantity or quality of food products at risk of contamination. External factors, on the other hand, include political market regulations, pandemics, or natural disasters such as climate change, earthquakes, and wildfires. The strategies to follow are aimed at supporting prevention and resilience in "The Day After" and recommending innovative actions [1].

Performance is conditioned by the existing structures, the behavior of the agents involved, and other factors. In this scenario, the environment impacts performance in different ways and with varying degrees of intensity, causing changes that affect the capacity for resilience. The main causes of such changes are of a health, climatological, socioeconomic or political nature, so the measures to be adopted are heterogeneous. The authors study the situation in Spain in view of the recent COVID-19 pandemic, its impact, and the responses.

Innovative mechanisms to drive business performance in food chains are faced with conflicts of interest due to the pluralistic nature of actors and internal and external risks that must be overcome with agile and durable improvements.

The complexity of food value chains has increased with urbanization, the globalization of flows as a result of international trade, and the variety of food products supplied. The number of stakeholders is also increasing. Thus, there is a greater probability of safety hazards, and finding a solution becomes increasingly difficult. Possible solutions include encouraging the consumption of local products and increasing the robustness of the value chain.

While risk is inevitable, its intensity varies according to the linkages in production, industry, and distribution, which could transmit instability. Managers and stakeholders must periodically analyze the situation to quantify and categorize risks as a part of decision making and planning. In food value chains, the challenge lies in considering the risks related to structure, conduct, and performance in key areas [2].

Materials and methods

The analysis is organized in accordance with the industrial organization paradigm, which includes robustness and resilience initiatives for health and socioeconomic recovery.

The industrial organization paradigm identifies three scenarios: structure (S), conduct ©, and performance (P). The first two interact with each other and affect the final result.

The structure scenario includes the organizational system; in the FVCN, this consists of successive links between production, transformation, distribution, and consumption, which must be strong to weather turbulent scenarios. The production link is embedded with EU policies, which are an external source of risk. These policies are geared toward adopting greener and more sustainable agriculture such that organic farming can comprise a quarter of total production, which would reduce the use of pesticides by half and fertilizers by one fifth.

The European Green Plan defines climate change and improving biodiversity and environmental quality as its guiding axes. However, there is skepticism regarding its viability. First, humanity must be supplied with food, which requires increasing production by 50% by 2030 and doubling it by 2050 to sustain a global

population of 9 billion people (according to FAO). However, depending on the particular circumstances, conversion to organic farming could mean up to a 20% reduction in production due to restrictions on the use of agrochemicals and genetic engineering. Farming legumes has been proposed to substitute nitrogen fertilizers, but the land area under cultivation would have to be increased nearly threefold.

Another factor that must be taken into account is that smaller livestock populations would reduce the volume of greenhouse gases emitted. This would then free up land area for agricultural crops, such as cereals, which would increase their supply on the market and then eliminate the disadvantage that lies in the low conversion rate for feed grains and livestock products. However, this would have an unfavorable socioeconomic impact on a very traditional sector.

The other links of the food value chain are also going through great changes in conjunction with major innovations in food processing. Such is the case of cultured meat grown through biotechnological processes, which is generating a gastronomic, productive, philosophical, and environmental revolution. Cultured meat has been launched on the market and has been well received as an innovation. The Spanish Ministry of Science has subsidized eight companies in this sector with 3.7 million euros. Other funding sources, such as the Bill & Melinda Gates Foundation, are promoting projects in this area, and it is estimated that by 2040, 30% of the meat consumed will be lab-grown.

Conduct includes the lack of coordination between the different links in the FVCN, which happens quite frequently in many countries. In Spain, there was an institution of the Ministry of Agriculture (FORPPA) that was responsible for coordinating stakeholders in various agricultural markets, such as the rice, fruit, vegetable, and milk markets.

In Cuba, some sectors (e.g., tomato, pork) suffer from a lack of coordination between producers, slaughterhouses, industry, and transportation agents. Haiti and Peru face similar problems in the rice, fruit, and vegetable markets.

The loss of products along the food value chain is another dimension of conduct that worsens in critical situations, such as pandemics. The causes of this are diverse, including improper storage facilities subject to pest attacks, poor market planning, inefficient industrialization, and waste in consumption. The data are striking [3]. A very important part of world production is not consumed due to post-harvest loss (up to 15%), supply control to maintain stable prices, or waste in consumption (25%).

The health terms “pandemic,” “epidemic,” and “endemic” refer to diseases occurring across different geographical areas (global, regional, or local) and durations (occasional, periodic, recurrent) and can be extrapolated to other disciplines such as economics, politics, or sociology. In the past, social movements have led to political revolutions in Central European countries after the fall of the Berlin Wall, the revolutionary movements in Latin America, local economic crises, and the Great Depression.

With respect to performance, there is an interdisciplinary contagious effect, as reflected by the coronavirus pandemic and the economic downturn in many countries, accompanied by social and labor adjustments. The food value chain network comprises chains with different actors that contribute value along the chain. The authors consider the impact of the organization of the food sector under an industrial organization model, the flows generated, and resilience and final performance (Figure 1).

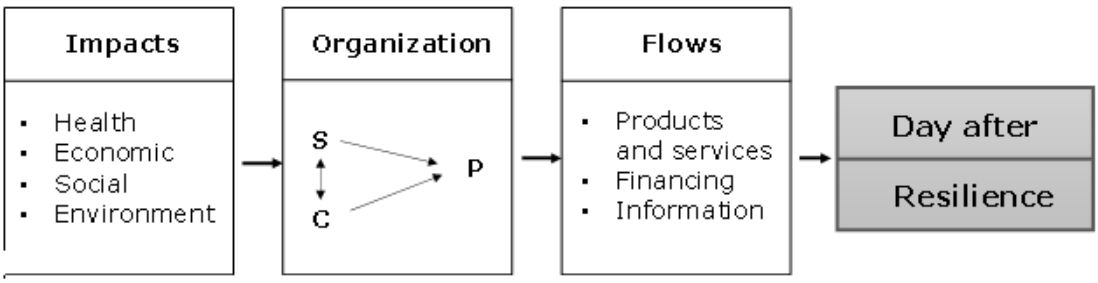

FIGURE 1.
Model of "Industrial Organization"
Source: Authors.

Health impacts are widely known, as the pandemic has affected the survival rate of the population and hospitalization services and left physiological and mental scars. Economic impacts are also relevant from both quantitative and qualitative points of view. The restrictions imposed by quarantining have ceased many activities. However, the agricultural sector was one of the least affected sectors in this regard, as it has the major responsibility responsibility of guaranteeing the food supply. New social circumstances have also had an impact on both individual and collective conduct and limited access to both food services and recreational and cultural activities. In turbulent situations such as the one we are experiencing, there are also environmental impacts as human behavior, and modifications made to the means and resources used for production.

Instability can also result from new trends in the human diet. In developing countries, the Mediterranean diet has been recommended for its positive health benefits. More recently, new diets have emerged, such as vegetarianism and veganism, the latter of which calls for a boycott of animal products for philosophical, health, and environmental reasons. Furthermore, the marginal population aspires to increase the consumption of these products, which may be viewed as a delicacy or luxury.

In turbulent situations, FVCN actors can use instruments to improve performance, robustness, and resilience, which increases transparency and coordination between public and private stakeholders [4]. In Spain, the AESAN, which is the Spanish agency for food safety and nutrition, is a useful instrument to ensure robustness in coordination with the European Food Safety Agency (EFSA). In fact, we consider that on the day after, resilience in combination with prior actions aimed at robustness is a key strategy to improve FVCN performance. Robustness alone is not enough when the impact is significant, and the food value chain actors need some flexibility to handle the situation.

Developing resilience in various fields (e.g., health care, markets, ecology, climate) over different time spans (short, medium, or long-term) does not necessarily require accurate future predictions but rather the capacity to design instruments to absorb the impacts and manage the changes. When discussing resilience, we must consider the resilience "of what," "to what," "for whom," and "over what timeframe" [5].

In the real market, there is a network of food value chains whose stakeholders need to define an adequate level of resilience in the following steps:

- Identifying which food chain is affected
- Pinpointing the origin of the problem
- Specifying the factors that may be involved in resilience actions
- Defining the number of activities to be undertaken in each period
- Monitoring progress and assessing practical alternatives

Time is a significant factor in measuring resilience across every link of the chain and is relevant to the stages of incubation, detection, and recovery. Incubation is the time period between the emergence of the turbulent scenario and the moment when the impact occurs. Detection is the time difference between the appearance of the shock and its detection. Traceability is a useful instrument to shorten the detection period. Finally, the recovery time is the period between the occurrence of the shock and a return to the former condition.

Another important factor in measuring resilience is the magnitude of the impact in the health, economic and social scenarios. The intensity and level of the shock depends on the immunity of the group affected, their age, vaccination status, and other conditions.

Adaptation to new situations is another resilience-related factor, as well as the degree of recovery toward the former situation. Some authors [6] propose quantifying the resilience of food supply chains through a mathematical model in which the resilience of the food supply chain to a food safety shock (R) gets closer to one in more resilient systems.

The resilience of food value chains is also related to the structure and behavior of all links. At the production level, ecological risks are more significant due to the overuse of agrochemicals, monoculture, and the lack of genetic diversity, which are intertwined with socioeconomic dimensions [7].

Traceability, standardization, and quality control allow the retrieval of more information but decrease the diversity of production and the market. To accomplish food value chain resilience, we need to combine actions and strategies at different levels and solve food security and health issues in heterogeneous markets, such as hunger or obesity.

Results

The analysis of the FVCN complement the strengths, weaknesses, threats, and opportunities (SWOT) analysis of the impacts and modes of action. In the case of Spain, positive outcomes **in managing to supply the population with basic products in a timely manner have been** achieved.

The surrounding environment interacts with the food value chain, by transmitting changes that can trigger the emergence of a new paradigm, or a methodological pattern that can largely explain the events affecting the reality of the chain.

For a more rigorous analysis, we can integrate the components of the SWOT matrix into the industrial organization model (Structure-Conduct-Performance), which can allow us to better understand the interactions between the links of the food value chain.

Thus, threats can turn into impacts of varying intensity and duration on the structure and conduct of the food value chain. Its capacity for adaptation or resilience depends on its strengths and weaknesses, which can cause structural and conduct changes.

Some threats to the chain may be intensified, others may be mitigated or eliminated, and eventually, new threats may be incorporated into the "day after paradigm..

New opportunities arise mostly from innovations, both in structure and conduct, giving rise to a new paradigm that shows good performance throughout the chain. In Schumpeterian terms, this could be called the "creative destruction" process [8] (Figure 2).

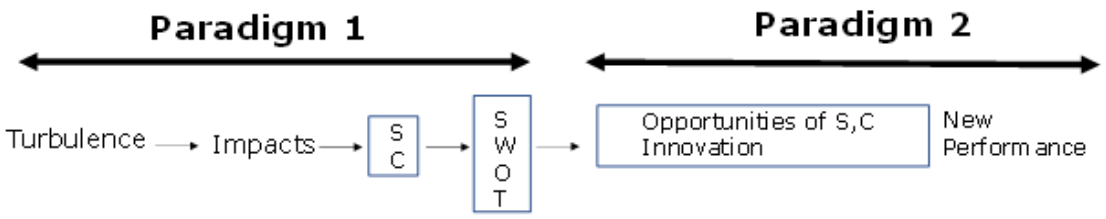

FIGURE 2.
The "creative destruction" process
Source: Mollenkopf, et. al, 2020 [8].

In brief, we can use the SWOT matrix of the food value chain, taking into consideration recent events. The strengths of the FVCN are derived from the fact that this is a basic sector for the survival of humanity. In addition, agriculture interacts with the environment, is a repository of culture and tradition in rural areas, and has an impact on climate change and the conservation of resources. The changes experienced by the sector can affect its form but not the essence of its survival.

Weaknesses affect survival and entail changes that will be experienced by chain actors. Structural alterations may occur, but the performance of production, processing and distribution must be assumed by various participants. One of the weaknesses stems from the heterogeneity of the components of the food value chain in its economic, social and cultural dimensions, which makes it difficult to reach agreements and coordinate strategies in health crises or natural disaster situations.

Threats imply possible impacts that force the implementation of new models, which are not always acceptable to all actors, who need technological, financial, or human resources for survival. Thus, digitalization is leaving many companies out of the market, climate change is forcing them to change or abandon certain crops, and the urban economic gap is leading to rural abandonment, which increases the distance between production areas and consumers.

Finally, opportunities rely on resilience, with the emergence of new innovative inventions. In the area of production, for instance, we have new technologies such as genetic engineering, crop methods, precision farming, smart irrigation and drones.

In general terms, management must address processes, digitization, market studies, information systems, new energy sources and materials, and gastronomic innovations that appear to be in line with consumption trends.

The performance of food value chains may be disrupted due to environmental conditions such as natural disasters, policy measures, and pandemics. Since 2019, COVID-19 has spread worldwide. The impact on demand, supply, and logistics has changed traditional activities, and countries have been forced to impose restrictions on trade flows.

Fortune (2020)[9], reported that 94% of their list of one thousand entrepreneurs experienced problems due to the pandemic. The main economic consequences were caused by restrictions on the domestic and foreign supply of food and services. Disruption of work in public and private institutions and firms, universities and schools, stores, restaurants, and other settings has led to a decline in commercial activities and revenues.

Recently, Goel et al. [10] pointed out that the loss of production capacity due to COVID-19 presents an opportunity to restore production levels through policy measures and investment. New relationships will emerge between risks and food value chain performance when some of the risk sources are the volatility of customer demand, supply regulation performance, logistic infrastructure, information, policy regulations, and environmental and operational management.

Food value chains are challenged by crises and food safety incidents. Therefore, the enhancement of the robustness of food value chains should be complemented by resilience [11].

Since it is impossible to have zero food safety risks, society has to manage its capacity to adapt when there are food safety hazards. The factors that determine resilience must be defined for the short, medium, and long terms, quantifying the impact with and without resilience applications. In addition, a cost- benefit evaluation of the potential actions must be carried out together with a study of the sustainability of the resilience measures in relation to the economic and human resources available.

According to the World Health Organization (WHO), 10% of the global population gets sick every year due to the consumption of contaminated food. According to AESAN, some of the most significant examples in Spain have been African swine fever, toxic oil syndrome, and mad cow disease, and others mentioned by the AESAN.

The way in which Spain dealt with African swine fever is an example of the effective resilience actions that can be undertaken in similar situations, including structural adjustments, the definition of the geographical areas infected, the implementation of isolation, movement and logistic restrictions, chain actors' declaration of behavior, costs, and results. African swine fever remained endemic in Spain from 1960 to 1995. During that period, the country's borders were closed to pig product exports for 30 years (though imports were allowed), and 3.5 million pigs were slaughtered, affecting 150,000 farms at a cost of 10,000 million pesetas.

The toxic cooking-oil scandal occurred in 1981, with more than 4,000 people dying and another 25,000 affected with physiological and mental sequelae. In 2000, BSE broke out with 800 cases and continued for three years, causing the death of five people and the decline of meat consumption by half.

Institutions have taken steps to prevent sanitary impacts, including product analysis, vaccination, or isolation measures.

In 2019, the AESAN (Operating protocols based on the results of the assessment for the selection of appropriate measures to prevent, reduce or eliminate risk by carrying out health, socioeconomic and environmental inspections) revealed that the measures taken delivered positive results as demonstrated by inspections regarding the following strains: Cysticercosis, (259,383), Echinococcus (66,259), Listeria (594), Salmonella (875), and Campylobacter (596).

In addition, a number of samples of ready-to-eat products were tested for the EU 2019 Zoonoses Report, namely, 62,019 samples of milk and milk products, 13,376 of fish and fishery products, 64,666 of meat and meat products, and 76,657 samples other types of products [14].

Conclusions

The FVCN is subject to impacts in all its links; there are critical periods, such as geopolitical conflicts, natural disasters, health or socioeconomic pandemics, among others, which force a change of paradigm as previous approaches are rendered obsolete. The resilience of the FVCN depends on the strength and nature of the integration of all its links.

There are a number of basic principles that must be upheld by the models proposed to respond to the demands of society.

First, the supply of food must be guaranteed, in quantity and with the quality needed, and at affordable prices.

Second, the system must be sustainable, oriented toward the Sustainable Development Goals (SDGs), and placing respect for the environment, climate change, biodiversity, and the improvement of ecosystems at the heart of all actions.

Third, consumption patterns must be adapted to economic and physiological conditions, age, habits and customs.

Generally, there is an overlap of the various strategies to be followed given the heterogeneity of the action scenarios. In the production link, conventional agriculture coexists with agroecology, and there is certain convergence between them [12].

The industrial link is dominated by SMEs, with a large group of well-known multinationals controlling the food system. Market objectives differ from one another, not only in terms of geographical boundaries but also in terms of the use of local or generic approaches, as well as the degree of innovation.

The distribution link has undergone strong transformations in recent decades, with a decrease in small retailers, a consolidation of supermarkets and a stagnation of hypermarkets.

Consumer habits are changing toward a preference for national products, mainly fruits and vegetables. Human society is hit by continuous critical events. Therefore, it is important to work on the strengths of the FVCN to prevent or mitigate major disruptions. However, in a non-zero risk situation, the FVCN has to improve resilience strategies for "the day after." Food safety is a social responsibility, and all relevant actors should be involved. This means that scientists, government authorities, and the population must cooperate. International analyses show that performance in this regard has varied.

The lesson learned is the importance of the surrounding environment in its multiple facets, such as food, biodiversity, and climate events, to ensure adequate food, natural anti-virus barriers, sustainability, and well-being. One possible solution relies on innovation in all links of the FVCN. Farmers, manufacturers, and distributors, with the participation of consumers, have joined forces to identify innovation niches with successful results. A recent study conducted in Spain [13] shows that innovative efforts in 2021 have been focused on enhancing existing brands and products (70%), finding new sales channels (64%), finding new products (64%) and searching for new markets (38%), while some have ventured into areas that are not part of their usual activities (21%). Also noteworthy is the promotion of new working methodologies with innovative strategies, supported by quantitative (79%) and qualitative (75%) market research, as well as artificial intelligence (2%). Product development times are being shortened, and a circular economy is being promoted together with sustainable packaging and the reuse of waste.

Countries such as China, where the COVID-19 pandemic began, responded with tight control over its population. However, in countries such as Spain, the actions taken were very heterogeneous, from tight controls and lockdowns introduced by the Central Government to the relaxation of measures and decentralization of authority to regional governments. The structure of the food value chain has had a significant impact, especially at retail establishments, restaurants, bars, and cafes. The behavior of citizens has also varied significantly.

In summary, COVID-19 has had a transitory impact on the economic and social life of countries, affecting the various sectors in different ways and therefore producing heterogeneous effects on food supply, services, and wages. According to the IMF, the consequences of the pandemic have been worse in Spain than in other European countries. In 2020, the GDP fell by 12.8%, although it experienced a recovery of 7.2% in 2021, but the unemployment rate remains at 16.8%. According to experts, recovery will be uneven and fragile and will take a long time. Global economic losses will reach $20 trillion between 2020 and 2025.

To design a resilience strategy, it is necessary to analyze the flows along the food value chain, together with the logistics of goods and services, information, and financial conditions. All of these aspects must be studied in multidimensional and multidisciplinary scenarios, from farmers to consumers, in consideration of different goals and health, socioeconomic, and environmental conditions.

The sensitivity to safety impacts varies depending on the product (cereals, meat, fruits, and vegetables, oil, fresh or processed products). There may be chemical and microbiological hazards, and the procedures to adopt will be of different natures, such as cooling, heating, cleaning, or following expert recommendations.

To reduce problems, it will be necessary to take action globally in a coordinated manner and without discrimination. However, countries that apply restrictions for climate change mitigation and environmental improvement must protect the market from the effects of such measures.

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Notes

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