sciendo

RURAL SUSTAINABILITY RESEARCH
47(342), 2022
ISSN – 2256-0939

Received: 5 March 2022 Revised: 1 July 2022 Accepted: 6 July 2022

Impacts of COVID-19 on the Food Supply Chain for Arable Crops in Latvia

***Ilze Upite, Dina Bite, Irina Pilvere, Aleksejs Nipers**
Latvia University of Life Sciences and Technologies, 2 Liela street, Jelgava, Latvia

Abstract. The COVID-19 pandemic has caused unprecedented stress to food supply chains, pointing to weaknesses in the labour, processing, transport and logistics spheres, as well as significant changes in demand. Food supply chains have shown considerable resilience in the face of such stress. Monitoring of the food sector during the COVID-19 pandemic indicates that the effects of COVID-19 on food supply, demand and access are interlinked processes and have a complex impact on food systems. In addition, high-value food supply chains in developed countries are even more complex, so countries need to respond quickly to restore them and also develop mechanisms that balance business and public interests and protect farmers and food business workers during future potential pandemic crises. The research aims to identify the main demand and supply side factors that affect the resilience of local and global food supply chains during the COVID-19 crisis, as well as assess the resilience of the supply chain for arable crops during the COVID-19 crisis in Latvia, identifying the main risk factors. The research found that arable crop farmers were relatively less affected by the COVID-19 crisis than other agricultural employees. The impact of the crisis was larger on the crop processing industry than on the other industries, and the main risk factors related to changes in demand and the industry's dependence on imported raw materials and the successful operation of export markets. Based on an in-depth risk analysis, the research developed recommendations for policy makers and actors in the agri-food chain that would improve the resilience of local (domestic) participants of the arable crop food supply chain in Latvia.
Key words: food supply chain, resilience, sustainability, COVID-19 pandemic risks, arable crops.

Introduction

The food system connects agricultural production with the actors in the chain, who carry out production processes, assembly, transportation and provide the necessary capacity. Maintaining logistical coherence is a key element in the food industry during a global disaster. The biggest challenge in the food supply chain is to obtain resources from suppliers and to ensure the flow of food from producers to buyers (Barman, Das, & de Kanti, 2021). Given the impact of COVID-19, ensuring the sustainability and resilience of the food system is now an even more pressing priority (The Organisation for Economic Co-operation…, 2020 April).

The concept of the food system helps to identify the whole set of activities of the food system, to identify the actors involved, their role and the diverse and complex interactions between them (Ericksen, Ingram, & Liverman, 2009). Food production, food processing and packaging, food distribution and retail form the food supply chain, but the overall food system also includes food consumption (Ericksen, 2008). In its food system definition, the FAO includes not only supply chain activities but also production support systems, food environments, consumption behaviours, diets and nutrition and health outcomes ("Food security and nutrition," 2020). FAO defines a sustainable food system using the common definition, which emphasises three traditional pillars of sustainability - environmental, economic and social: a sustainable food system means ensuring food and nutrition security for all without compromising the economic, social and environmental foundations of food and nutrition security for future generations

* Corresponding Author's email: ilze.upite@llu.lv

DOI: 10.2478/plua-2022-0007

(Nguyen, 2018). Given the economic, social and environmental dimensions of the food system, all 17 United Nations' Sustainable Development Goals can be linked to the food system.

An extensive study of various approaches to defining a sustainable food system points to groups of researchers who emphasise certain dimensions in terms of sustainability but do not pay enough attention to other dimensions. These research groups mainly link sustainability to one of the following areas: agriculture, nutrition, socio-ecology, a value chain for nutrition and agroecology (Béné *et al.*, 2019). FAO experts in their latest studies emphasise that a sustainable food system includes not only food security dimensions such as access to food for all the population, inclusion, regeneration, health and nutrient adequacy, but also resilience to ensure its stability in times of crisis ("Food security and nutrition," 2020). In a study on sustainability and resilience in agrifood systems, C. Lamine (2015) concludes that sustainability has long been used as a term describing the food system, while the term resilience has appeared in the literature later, and resilience has been defined "in a more dynamic way, in terms of the ability to cope with shocks and stresses". Researching theories about the relationships between the concepts of sustainability and resilience, O. Renn (2020) summarised several groups of approaches, one of which considers resilience to be a part of sustainability. According to this approach, both sustainability and resilience have a maintenance or sustaining function. Therefore, this research study focuses on the issue of food supply chain resilience as part of ensuring the sustainability of the food system based on the experience gained in the Latvian arable crops sector.

During the COVID-19 pandemic, opportunities arise to identify vulnerabilities in the food system in order to identify the changes needed to increase the industry's resilience to future shocks and challenges. It should be noted that some food and agricultural companies are able to adapt their business to the changes taking place quickly enough, so it is important to understand these success factors in order to learn lessons and avoid the most negative consequences in the future (Organisation for Economic Co-operation…, 2020 April). In a highly globalised world, food supply chains tend to be long, distant and anonymous and potentially may be influenced by an enormous number of different reasons and social agents (Serrano & Brooks, 2019). Complicated food supply chains are mainly associated with the long-term transportation of raw materials, environmental challenges and deteriorating quality. In order to increase efficiency in the food industry, stocks have been reduced, resulting in an 'on-demand' system that depends on efficient transport. Under conditions of resilience, the impact of such production and supply chains should be reviewed, especially during the COVID-19 pandemic (Bakalis *et al.*, 2020). There are widely admitted problems concerning systems` traceability, the inability to maintain the safety and quality of products, inadequate communication between parties involved, rising supply chain costs as well as a failure to track and control inventory in warehouses and stores (Asaad, 2018). Food availability during COVID-19 was affected by dependence on long supply chains, imported food and just-in-time supplies, indicating that the current food system is not prepared for sudden and unexpected increases in food demand (Colafemmina, El Bilali, & Capone, 2020).

The question about food supply chain resilience comes to the surface when there are some disruptions in the flow of the products that makes the food supply system vulnerable. There are four main areas that must be considered in order to cope with uncertainty: knowledge management, sourcing decisions, cooperation between different actors in the supply chain and logistics. Supply chain resilience is enhanced by effective action in these areas, since these activities help to achieve the flexibility, adaptability and consistency that researchers consider to be the determinants of supply chain resilience (Umar, Wilson, & Heyl, 2017). In the context of food availability, resilience is the ability of communities and households to cope with negative consequences while maintaining their long-term functioning and well-being (Béné, 2020). The Resilience Measurement Technical Working Group defines resilience as the ability to prevent the long-term adverse effects of stressors and shocks (Constas, Frankenberger, & Hoddinott, 2014). As C. Folke (2006) defined, resilience is about the biggest challenge: maintaining the functioning of the food system and ensuring adaptability and flexibility in times of environmental and market crises. An essential feature of interdependent systems is that the interruption or deterioration of one system can cause similar performance problems in other related systems. Interdependence between system actors can have the potential to have a very strong "ripple effect" on the food supply system as a whole (Béné, 2020). For example, production or transport problems can lead to food shortages, and the food industry, which is dependent on exports and imports, faces problems because raw materials can be difficult to supply (Buldyrev *et al.*, 2010).

There are some early assessments concerning food supply chains during the COVID-19 crisis. For instance, actors in the food supply chain need to adapt quickly to demand shocks, including unpredictable changes in food purchasing patterns, and prepare for

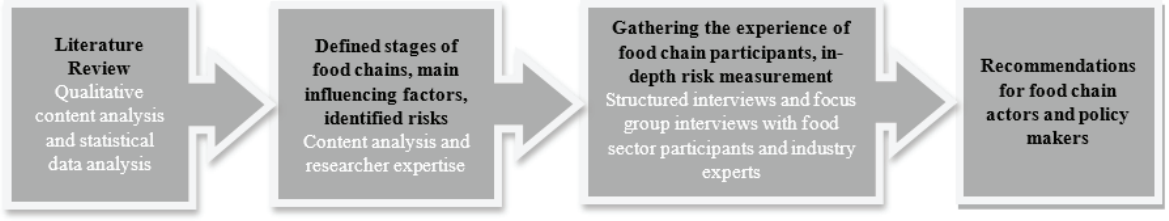
supply-side shocks that may be associated with labour shortages, transport and supply problems (Hobbs, 2020). In spite of fast reorganisation and adaption to the challenges, some effects will last for a longer period. Some scientists expect orientation towards online grocery deliveries and increased interest in local foods as an effect of COVID-19 (Deconinck, Avery, & Jackson, 2021). The COVID-19 crisis highlights the centralised characteristics of food systems, and therefore decentralisation of the food system is proposed as a potential solution, placing an emphasis on the sustainability of the system and local products, thereby lowering transport and storage costs (Petetin, 2020). During the last decades, literature about alternative food networks emerged, emphasising the ability of networks to contribute to food security by reducing geographical, economic and social distances between producers and consumers. The need to return to the localisation of food is being discussed in the academic, political and business environments (Partalidou, 2015). The so-called short food supply chains are considered as a way to create new types of supply and demand, assigning value and meaning for the production, and even contribute to rural development (Marsden, Banks, & Bristow, 2000). The experience built up during the COVID-19 pandemic indicates that small supermarkets performed best during the lockdown, as people wanted to avoid long journeys in order to reduce the risk of infection and comply with government safety measures (Coluccia *et al*., 2021). In summary, food supply chains are undergoing significant structural and functional changes within the system during recent years. COVID-19 serves as an additional reason to rethink and reconstruct existing modes and to adapt them to the new circumstances and requirements.

Accordingly, the **research aims** to identify the main factors that affect the resilience of local and global food supply chains during the COVID-19 crisis. To achieve the research aim, the following specific **research tasks** were defined: 1) to identify the main demand and supply side factors affecting the resilience of the food supply chain during the COVID-19 crisis; 2) to assess the resilience of the arable crop food supply chain during the COVID-19 crisis in Latvia, identifying the main risk factors.

The paper consists of four parts. The methodology part explains the methodological framework for the present research and methods used. The literature review describes the effects of the main supply and demand side factors that affected the activities of actors at various food supply chain stages during the COVID-19 crisis and reduced the resilience of the food supply chain during the crisis, as well as discusses the long term changes. The research result part summarises the findings on the situation at the stages of the food supply chain for arable crops (cereals, legumes and potato) in Latvia during the COVID-19 pandemic. The conclusions provide locally appropriate solutions, developed by the authors, adapted to crisis and post-crisis conditions that would improve the resilience of local (domestic) participants of the arable crop food supply chain in Latvia.

Materials and Methods

The relevant experience in Latvia was gained during the first wave of the pandemic in 2020 and reported under the national research programme "COVID-19 Impact Mitigation", project "Towards the Post-pandemic Recovery: Economic, Political and Legal Framework for the Preservation of Latvia's Growth Potential and Increasing Competitiveness", subproject "Restructuring of local agricultural and food supply chains and strengthening of resilience in crisis and post-crisis conditions in Latvia" (Górnaś *et al*., 2021). The research object is the resilience of the food supply chain during and after global pandemic crises, while the research subject is the arable crop food supply chain in Latvia during the COVID-19 pandemic. The research employed comparative analysis and the logical construction method. The main factors affecting the activities of the actors in the food supply chain were defined and relevant risks were identified by using the data obtained from the content analysis and the expertise of the researchers involved in the research.



Source: constructed by the authors

Figure 1. Methodological framework of the research.

For the purposes of the research, risk matrices were developed (see Table 2 and 3) and at the later stages of the research, appropriate mitigation measures were developed after identifying the risks with the highest probability of occurrence and impact. Fifteen in-depth interviews with national crop growers, representatives of processing companies and industry experts, as well as focus group interviews at a seminar for crop sector entrepreneurs and industry experts were conducted to identify, assess and recommend risk prevention measures for COVID-19 based on an expert assessment. The interviews provided qualitative measurements of the behaviour of the food supply chain actors during COVID-19, the challenges and risks they faced and the solutions they devised to mitigate the risks. In addition, the food chain actors provided quantitative assessments of the risks – the probability of their occurrence and the impact on their businesses under the conditions of the pandemic crisis. The main conclusions drawn from the in-depth and focus group interviews are analysed in the discussion section of the paper, thereby helping to explain the need for risk mitigation measures, while a risk assessment by the industry experts has been used to compile the risk matrices. Based on the information obtained during the interviews and the seminar as well as on the researchers' expertise, a risk characterisation was performed and the risks identified were assessed on a five-point scale in two dimensions: the probability of occurrence of the risk and the impact of the risk. The risks identified were divided into two groups: external and internal (see Table 1 for a breakdown of risks in the risk matrices).

The production and processing risks that need to be managed were identified from the risk matrices. These are the risks representing very high (catastrophic) and high (critical) risk levels (with the risk scores ranging from 8 to 25).

The authors used related research papers and information provided by the Food and Agriculture Organization of the United Nations (FAO), the Organization for Economic Cooperation and Development (OECD), the Ministry of Agriculture (MoA) and the Central Statistical Bureau (CSB) of the Republic of Latvia.

Agriculture and the food processing industry is an important sector of the economy of Latvia, which plays a significant role in the economy in terms of value added, exports, employment and taxes paid. The food and beverage industry is one of the largest manufacturing industries in Latvia and accounts for approximately one-fifth of the value added of manufacturing. In 2020, the value added of the industry at current prices was EUR 608 million. The food industry in Latvia is mainly orientated towards the domestic market, as approximately 60% of its output is consumed in the domestic market. In 2020, the pattern of sales of food products and beverages was dominated by meat and dairy products (42%), fish processing products and preserves (11%), beverages

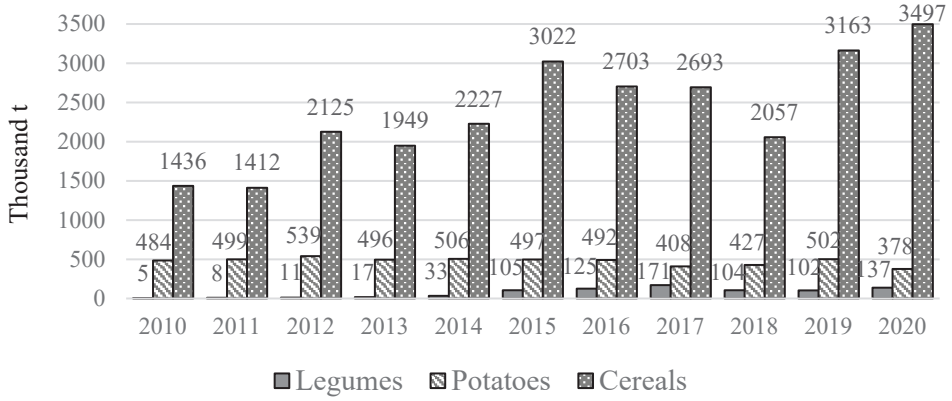
Table 1

Types of risks included in the risk matrices

Producers of cereals, pulses and their products	Producers of potatoes and potato products
Internal risks	
Management risks	
1. Difficulties in planning economic activity ahead 2. Lack of experience	1. Difficulties in planning economic activity ahead 2. Lack of experience
Staff risks	
3. Redundancies due to closure or downsizing 4. Dependence on the physical presence of the workforce in the company 5. Shortage of labour 6. High density of employees 7. Labour contact control 8. Social distancing requirements	3. Redundancies due to closure or downsizing 4. Dependence on the physical presence of the workforce in the company 5. Shortage of labour 6. High density of employees 7. Labour contact control 8. Social distancing requirements
Procurement risks	
9. Shortage / unavailability of raw materials on the market 10. Lack of packaging materials / supply problems 11. Rise in raw material prices 12. Downtime of cooperation partners	9. Shortage / unavailability of raw materials on the market 10. Lack of packaging materials / supply problems 11. Rise in raw material prices 12. Downtime of cooperation partners

Production risks	
13. Decrease in production 14. Reduction / downtime 15. Increase of work intensity	13. Decrease in production 14. Reduction / downtime 15. Started construction, etc. project stoppage
Storage risks	
16. Increase in stocks of manufactured products 17. Storage problems with products with a short shelf life 18. Freezing of current assets	16. Increase in stocks of manufactured products 17. Storage problems with products with a short shelf life 18. Freezing of current assets
Realization risks	
19. Increased competition from indirect competitors unable to compete with their direct supply and loyalty programmes 20. Ineffectiveness of current product promotion activities in the market (e.g., food tastings, fairs, exhibitions, etc.) 21. Decreased customer loyalty and support for products supplied through local short food chains due to increased hygiene risks.	19. Increased competition from indirect competitors unable to compete with their direct supply and loyalty programmes 20. Ineffectiveness of existing product promotion activities in the market (e.g., food tastings, fairs, exhibitions, etc.) 21. Decreased customer loyalty and support for products offered in local short food chains due to increased hygiene risks.
Settlement and financing risks	
22. Additional costs to adapt to an emergency 23. Decrease in revenue 24. Problems in receiving payments for products sold 25. Inability to settle credit obligations 26. Failure to pay monthly payments 27. Increase in logistics costs 28. Tax arrears	22. Additional costs to adapt to an emergency 23. Decrease in revenue 24. Problems in receiving payment for products sold 25. Inability to settle credit obligations 26. Failure to pay monthly payments 27. Increase in logistics costs 28. Tax arrears
External risks	
Market risks	
29. Market uncertainty 30. Difficulties in finding new outlets to replace closed ones 31. Decrease / increase in demand 32. Temporary shortage of food on the market 33. Rise in commodity prices 34. Decrease in customers' solvency	29. Market uncertainty 30. Difficulties in finding new outlets to replace closed ones 31. Decrease in demand 32. Temporary shortage of food on the market 33. Rise in commodity prices 34. Decrease in customers' solvency
Industry risks	
35. Dependence on exports 36. Imports from third countries	35. Dependence on exports 36. Imports from third countries
Social risks	
37. Buyer's excitement 38. Change of buyers' habits 39. Communication problems	37. Buyer's excitement 38. Change of buyers' habits
Political and legal risks	
40. Increase in hygiene requirements for entrepreneurs 41. Intensified monitoring of the FVS in companies 42. Various physical restrictions at national borders 43. Driving time restrictions for car drivers 44. Availability of services of state institutions is deteriorating 45. The role of leguminous crops in support schemes	39. Increase in hygiene requirements for entrepreneurs 40. Intensified monitoring of the FVS in companies 41. Various physical restrictions at national borders

Source: the authors' expertise and industry expert evaluation during the interviews and seminar



Source: authors' construction based on Central Statistical Bureau of Latvia, 2021; Latvia Ministry of Agriculture, 2021

Figure 2. Cereal, potato and legume production in Latvia, 2010-2020.

(11%), confectionery and bakery products accounted for 10%, fruit and vegetables processing (5%) while other food products made up 21%. The largest share of exports in the sales of food and in the beverage sector in 2020, as in previous years, was fish processing products and preserves (79.7%) and processed fruit and vegetable products (52.4%). The number of employees in the food industry in 2020 was 18.2 thousand, and their share in total employment was 2%. The total value of agricultural output at basic prices in 2020 reached EUR 1572 million. The essential role of grain production in Latvian agriculture is characterised by the large proportion of grain in the value of final agricultural output – 38.5%. In 2020, the proportion of potato was 3.1%, while that of legumes was 2.1% (Latvia Ministry of Agriculture, 2021).

The production of potato and pulses has increased in recent years, while the cereal and legume sector is characterised by a high level of self-sufficiency, which far exceeds the needs of national consumption. Most of the products produced, especially grains, are exported. Cereals, legumes and their products are sold through traditional zero, one-level and two-level sales channels; however, the role of export-orientated cooperatives and wholesale companies in managing grain and legume sales should be emphasised as well (Figure 2).

Legumes are valuable fodder protein crops and soil improvers, and although the motivation to grow legumes has been significantly increased by the introduction of the new system of direct payments, the area of legumes has been declining in recent years. Even though the potato area represented less than 2% of the total cropped area in 2020, potato production in Latvia has long traditions. However, potato production decreased, as the potato is a resource-intensive crop that makes small potato farms increasingly uncompetitive. Potatoes produced in Latvia are mostly used for domestic consumption, and the output of potatoes practically meets the needs of the population of Latvia. In addition to traditional sales channels, direct marketing is practised in selling potatoes, which can be done by various agents in the food supply chain – both producers and wholesalers.

Although COVID-19 has caused problems at all stages of the food supply chain, various sectors and individual products have been affected in different ways, and disruptions have occurred at different stages of the food supply chain (Organisation for Economic Co-operation…, 2020 July). The impact of the COVID-19 pandemic on the food and agricultural supply chain comes from two perspectives: food supply and food demand (Barman, Das, & de Kanti, 2021). Both supply and demand forces must be taken into account when analysing the impact of any crisis. The decline in global food supply caused by any emergency reduces incomes for most farmers and increases food prices for most consumers. The fall in food demand caused by the recession is reducing food prices and farmers' incomes. Farmers are adversely affected by both negative demand shocks and negative supply shocks (Savary *et al.*, 2020).

Results and Discussion

1. Main Demand and Supply Side Factors Affecting the Resilience of the Food Supply Chain During the COVID-19 crisis

Demand side shocks. **Closure of the HoReCa (Hotels, Restaurants and Café) sector, schools, recreational places, open-air markets, street vendors and other informal markets.** Additional pressures on the food retail sector caused by the COVID-19 pandemic include the closure of restaurants, cafes, bars and hotels and the increase in

the proportion of work from home. As most of these purchases have now been shifted to retail, a number of problems arise, as products intended for the HoReCa industry and those intended for retail differ in terms of both size and logistics. In addition, the consumption patterns of the population at home and in public catering establishments are different. Therefore, the application of catering products to retail needs involves additional costs and time (Organisation for Economic Co-operation…, 2020 June; 2020 April; Hobbs, 2020; Petetin, 2020; Coluccia *et al*., 2021).

Shifts in consumer behaviour. Unpredictable consumer behaviour during the crisis has created major problems for large supermarket chains, with a strong emphasis on cost-effectiveness. The relatively small stocks and continuous product flows that underpin the efficiency of such stores created problems in flexibly adapting to shoppers' panic buying periods and changing shopping habits (Hobbs, 2020). The COVID-19 crisis highlights that "just-in-time characteristics of the food supply chain" is ill-suited to the challenges of crisis situations. The goal of such supply chains is to guarantee the freshness of the products and to reduce waste, but they must be coordinated and efficient, and therefore problems in one stage in the chain have a significant impact on the successful functioning of the other stages. However, it should be noted that supply chains quickly adapted to demand signals and increased product flows, thus reducing the problem of short-term deficits and stocks (Petetin, 2020). Observations show that food chain companies are adapting to changes in demand by improving inventory management, changing the production profile, introducing online sales and hiring additional staff (Organisation for Economic Co-operation…, 2020 April). Secondly, COVID-19 has led to a sharp shift in consumer demand from "food away from home" to food consumed at home, requiring significant changes in the functioning of food supply chains (Organisation for Economic Co-operation…, 2020 July). Demand has also shifted from higher value items to basic and ready-to-eat foods that can be stored for a long time (Organisation for Economic Co-operation…, 2020 April). Restrictions on movement and other epidemiological measures have led to an increase in home cooking and food crafts, as people started to prefer staple fibres or simple foods (Colafemmina, El Bilali, & Capone, 2020). COVID-19 has increased public concerns about their mental health, leading to an increase in demand for products with potentially positive effects on mental health (Barman, Das, & de Kanti, 2021). As all markets and street outlets were closed, supermarkets became the main places to shop. A number of significant changes were observed in consumers' shopping habits: increasing shopping on internet platforms, decreasing shopping density, increasing takeaway and take-home orders, including using on-line platforms, social communication on the internet, also in food-related areas (Bakalis *et al.*, 2020; Petetin, 2020).

Supply Side Shocks. **Labour shortage.** Labour shortages caused by sickness or distance requirements caused significant problems, especially in highly concentrated sectors. In the agricultural sector, especially in industries with high seasonal labour demand or labour-intensive production, problems were compounded by restrictions on labour mobility from other countries (Organisation for Economic Co-operation…, 2020 April). For many products in the northern hemisphere, the availability of labour during the harvest season is essential. There is a shortage of around one million seasonal workers in agriculture in the European Union, which can have a significant impact on production and lead to higher prices for fruit and certain vegetables (Coluccia *et al*., 2021; Stephens *et al.*, 2020). Labour shortages in the agricultural sector existed even before the COVID-19 crisis. Due to the intensification of agricultural production and industries with seasonal labour demand, the level of agricultural mechanisation and the demand for higher-skilled labour might increase in the future (Barman, Das, & de Kanti, 2021). The social distancing requirements introduced and the illness of workers as a result of the COVID-19 pandemic have caused problems and declining production in many food processing plants in Europe and North America, especially because the operational model of many processing plants is not suitable for distancing requirements (Savary *et al.*, 2020). Due to the higher workload, the meat processing industry has suffered more as a result of the COVID-19 pandemic, while grain processing has suffered less due to its largely automated nature (Organisation for Economic Co-operation…, 2020 July).

Disruptions to transportation networks. The weak point in the food supply chain is transport and logistics, and the scale of the problems caused by the COVID-19 pandemic is directly related to the mode of transport. Cereals and oilseeds are usually shipped in bulk, and no major problems have been observed in such large consignments, with low bulk prices. Dairy products and meat are usually delivered in refrigerated containers and by truck. The biggest problems have been observed in the supply of perishable high-value products, which usually take place with passenger aircraft because the air transportation was significantly disrupted (Organisation for Economic Co-operation…, 2020 June). As a result, the exports of products such as fruit, vegetables and seafood suffered

the most, as air fares have risen due to declining volumes, quarantine measures have been introduced and border inspection times have increased, including due to staff shortages. At the same time, the transport of cereals was not particularly affected, as they can be loaded and dispatched with minimal labour input (Organisation for Economic Co-operation…, 2020 April; 2020 June; 2020 July).

Shortage of resources. There is a risk that the quarantine measures and transport restrictions introduced as a result of the COVID-19 pandemic could disrupt the supply of raw materials for the food industry. No information is currently available on major supply disruptions in developed countries, but it is possible that farmers will have difficulty obtaining some inputs (Organisation for Economic Co-operation…, 2020 April; 2020 June; 2020 July). The supply of agriculturally important raw materials such as fertilisers and energy has taken place so far, and fertiliser prices have been relatively low. Seed material has also been available so far, but there is a risk that its supply may be disrupted. In any case, there is a possibility that some transport difficulties will develop locally. During the season, farmers may also have problems with reduced access to finance for the purchase of working capital if financial institutions are closed due to a pandemic (Devereux, Béné, & Hoddinott, 2020).

Export restrictions. A major problem is the export restrictions that are being imposed in some countries despite the fact that the World Trade Organization, the FAO and the World Health Organization do not support the introduction of such restrictions and recommend actors to "show solidarity, act responsibly and adhere to our common goal of enhancing food security, food safety and nutrition, and improving the general welfare of people around the world". Although restrictions are introduced to protect and ensure the availability of food on the local market, they affect certain basic crops more, such as cereals, and as a result their effects can cause significant disruption to the global food system (Petetin, 2020). Although export restrictions could benefit the country's population in the short term, it should be noted that there will be many negative consequences such as declining domestic production, falling agricultural prices, the loss of reputation and global market share that later might subsequently affect the prices and availability of other foods ("Why export restrictions," 2020). Despite the export restrictions imposed so far, international supply is still sufficient, but sooner or later the negative consequences will affect consumers and food prices will rise (Petetin, 2020).

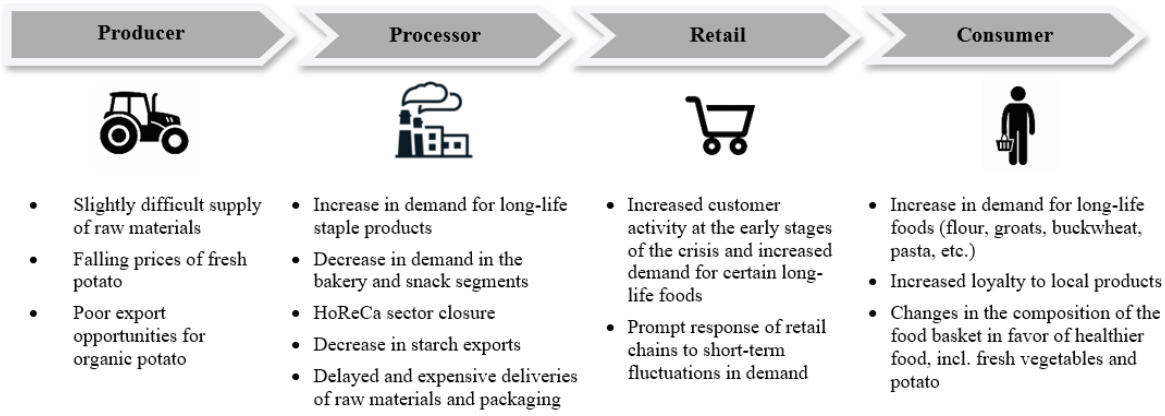
Long-term Changes. In view of the demand and supply side disruptions caused by the COVID-19 pandemic, the potential long-term effects on food supply chains need to be considered (Hobbs, 2020). However, it should be noted that any long-term prognosis is uncertain and depends on the duration of the pandemic, the magnitude of the change and the change in behaviour following COVID-19 (Weersink et al., 2021). If, as a result of the crisis, global unemployment rises in the long term and incomes fall, the share of food expenditure in the total household expenditure basket will increase. Food prices will also rise, as supply disruptions may persist and the demand for food may increase (Petetin, 2020). If household incomes continue to decline, buyers are also expected to shift to other product groups in the long term, for example, the importance of price will increase and the buyers will replace more expensive products with more affordable ones (Hobbs, 2020). As a result, the total amount of calories consumed may remain in the long term, but the quality of the diet may deteriorate. With a shrinking food budget, people can reduce their consumption of the most expensive and valuable products such as milk, meat, fruit and vegetables, and replace them with less price-elastic staple products such as cereals and roots (Colafemmina, El Bilali, & Capone, 2020; Schmidhuber, Pound, & Qiao, 2020).

Changes in customer behaviour can change retailers' contractual relationships with suppliers, and the retail chains can put stringent cost-cutting measures in place that will have a negative impact on low-profit processing and supply companies. Smaller retailers with less capacity and availability of resources might face greater challenges (Hobbs, 2020). As the pandemic continues, food supply chains could move towards greater consolidation and product diversification, as well as greater process automation, given the negative impact of the pandemic on labour supply (Weersink *et al.*, 2021). The challenges posed by the pandemic are likely to increase consumer loyalty to local food (Hobbs, 2020).

2. Latvian Experience in the COVID-19 Pandemic

Figure 3 shows what arable crop food supply chain actors and consumers gained during the first wave of the COVID-19 pandemic in 2020 in Latvia. One can conclude that the participants of the Latvian arable crop food supply chain were influenced by both supply and demand side factors; however, the demand side factors had a greater impact.

The results obtained for food supply chain participants in cereals, legumes and potato sectors are presented in the risk matrices for both the production and processing areas. As the situation in the cereals and pulses sector was similar, a single risk matrix was developed for both sectors (see Table 2) and a separate risk matrix was developed for potato production and



Source: literature review and expert interviews conducted by the authors, 2020, Latvia University of Life Sciences…, 2021

Figure 3. Impacts of Covid-19 at various stages of the cereal, legume and potato food supply chain in Latvia.

Table 2

Risk matrix for the production and processing of cereals and pulses

Qualitative explanation of the risk:		Impact of the risk (consequences)				
Very high (catastrophic) risk						
High (critical) risk						
Moderate (increased) risk		5 (catastrophic)	4 (major)	3 (moderate)	2 (minor)	1 (insignificant)
Low risk						
Probability of occurrence of the risk	5 (almost certain)	P4.	R4. **P31.**			
	4 (very likely)	**R35.**	R9., R23., R24., R25., R26., **R31.** P9., P10., P13., P14., **P35.**	R28. P6., P7., P12., P23., P24., P25., P26., P27., P28.	P22., **P41.**	
	3 (possible)		R16., R18. P15., P16., P18.	R1., R2., **R42., R44.** P1., P2., P3., P5., P20., **P29., P42., P44.**	R12., R22., **R29., R30.** P11., P17., **P30., P34., P38., P40., P43.**	**R40.**
	2 (unlikely)			**R45.**	P8., P19., P21., **P36., P39.**	R11., R20., R21., **R36., R39., R41.** **P32.**
	1 (very rare)					R3., R5., R6., R7., R8., R10., R13., R14., R15., R17., R19., R27., **R32., R33., R34., R37., R38., R43.** **P33., P37., P45.**

Source: industry expert evaluation during the interviews and seminar and the authors' expertise

processing (see Table 3). Production risks are marked with R in the risk matrix, processing risks – with P, while external risks are highlighted in bold.

Cereals and legumes. Cereal and legume producers have been relatively less affected by the COVID-19 crisis than those employed in other agricultural industries. The producers were largely protected by contracts with cooperatives, processors and wholesalers during the first wave of the pandemic. Problems for the cereal and legume producers were caused by the uncertainty caused by the crisis at the beginning of the season, as doubts arose regarding the availability of raw materials. Some problems with the supply of machinery and spare parts were not resolved, which, in the worst case, caused problems for the farmers who attracted European funding for the purchase of machinery. In terms of production volumes, cereal and pulse producers were optimistic, as the demand for basic products in the food sector always remained stable, but the situation in the sector could deteriorate significantly if grain exports were to be disrupted. Most of the farmers use imported fertilisers and pesticides, making producers dependent on imported raw materials.

If the supply of raw materials for production does not deteriorate during the Covid pandemic, producers of basic food products will be able to supply three times more products than the needs of Latvian consumers. The main challenge for large producers of long-life processed cereal products (flour, groats, buckwheat, pasta etc.) was to balance the domestic market demand with the export demand, and due to the decision to supply the domestic market first, export deliveries were limited. Snack producers could be hit

Table 3

Risk matrix for potato production and processing

Qualitative explanation of the risk:		Impact of the risk (consequences)				
Very high (catastrophic) risk						
High (critical) risk						
Moderate (increased) risk		5 (catastrophic)	4 (major)	3 (moderate)	2 (minor)	1 (insignificant)
Low risk						
Probability of occurrence of the risk	5 (almost certain)	P4., P13., P16., P23., **P30., P31.**		**R29., R31.** P7., **P29.**		
	4 (very likely)		R1., R9., R18. P1., P9., P14., P24., P25., P26., **P35.**	P15., P28., **P34.**	**R34., R35.** P2.	
	3 (possible)			R4., R16., R20., R23. P3., P18., **P38., P41.**	R3., R22. P6., P12., P21., P22., P27., **P40.**	R12.
	2 (unlikely)				R2., R8., R14., R20., R24., R25., R26., R28., **R36.** P11., P19., **P32., P39.**	R10., R11., R13., R21., **R39., R40., R41.** P8., P10.
	1 (very rare)					R5., R6., R7., R15., R17., R19., R27., **R30., R32., R33., R37., R38.** P5., P17., **P33., P36., P37.**

Source: industry expert evaluation during the interviews and seminar and the authors' expertise

harder by the crisis, as the demand declined during the crisis, and producers whose products are largely consumed by the HoReCa sector, which went out of business during the crisis, could face larger problems. In general, processors are able to adapt flexibly to the challenges posed by the crisis by developing new products (for example, the bread product line "Bake Yourself"), finding new outlets where necessary, reducing production and offering products in line with market demand.

Potato. The risk factors affecting demand during the first wave of the Covid-19 crisis are causing problems for potato producers to varying degrees, depending on the type of production. Potato producers who delivered potatoes for processing were not affected, as potato processing companies took risks during the first wave of the crisis. The demand for fresh potatoes remained stable, but the price of potatoes fell. Potatoes destined for processing in neighbouring countries entered the market of Latvia, as companies in the HoReCa sector ceased operations and exports of organic potatoes also stopped. Regular consumers of processed potato products ceased to exist due to the banning of sports and cultural activities, the closure of the HoReCa sector and the reduction of potato starch export opportunities, so the potato processing industry also suffered significantly during the Covid-19 crisis. In the potato processing industry, businesses have to look for new markets or wait for the situation in the HoReCa sector and retail sales to improve.

Table 4 summarises the risks which, according to the analysis carried out, are very high and high risks for arable crop producers and processors (risk scores ranging from 8 to 25), and their management requires risk mitigation measures. Recommendations for risk reduction have been prepared based on the opinions of the survey respondents and the experience of the authors of the present research.

Overall, the crop producers and processors identified several internal risks related to the possibility of employee illness, the activities of business partners,

Table 4

Recommendations for mitigating the impacts of risks identified for arable food supply chain companies in Latvia

Risks to manage	Recommendations for risk mitigation
Internal risks	
Dependence on the physical presence of the workforce in the enterprise	• On-site training in companies; • Guidelines for action during epidemiological restrictions; • Staff replacement plan, introduction of remote communications; • Shift work schedule in processing companies, process automation, installation of communication control systems.
Unavailability of raw materials on the market	• "Green" corridors for delivering raw materials and packaging; • Stockpiling of raw materials in companies.
Decrease in production/ downtime/suspension	• Restructuring of production according to demand, development of new products and introduction of marketing activities; • Government support in cases of employee downtime; • Government support to cope with the difficulties caused by rising stocks and declining turnover.
Increase in stocks of manufactured products/ freezing of working capital	• Availability of loans for investment to increase storage capacity and eased credit conditions; • Availability of loans for the purchase of current assets and interest relief for the purchase of current assets; • Government support to cope with the difficulties caused by rising stocks.
Decrease in revenue/inability to settle payments	• Government support for obtaining funds, for example in the form of direct grants, loans and loan guarantees.
External risks	
Decrease in demand	• Stimulation of local consumption and loyalty to local products; • Introduction of a reduced VAT rate for all foodstuffs.
Dependence on exports	• "Green" corridors for delivering food; • Support of national institutions for the export of food; • Support for stimulating the development of export-capable companies and increasing their export capacity.

Source: literature review and expert interviews conducted by the authors, 2020, Latvia University of Life Sciences…, 2021

as well as changes in the demand for their products, as the risks with the highest impact. The decrease in demand and dependence on exports were the main external risks admitted by the crop producers and processors. The possibility of employees becoming ill is a real threat to any company, yet the grain, legume and potato producers interviewed did not face this problem during the first wave of the COVID-19 pandemic. Agricultural cooperatives, which have a large number of employees, especially during the production season, who cannot be replaced or whose duties cannot be performed remotely, e.g., the only representative of the cooperative in the region or the head of the laboratory, face a very high risk of illness for their employees. There is an increased risk of illness for workers in processing plants; however, as world experience shows, it is lower in highly automated arable crop processing than, for example, in the meat processing sector (Organisation for Economic Co-operation…, 2020 July).

In Latvia, a significant part of grain and pulses is sold to cooperatives and wholesale companies, which export most of their products. Therefore, a serious threat to the development of the sector is the potential closure of export markets because of the deepening crisis. In the worst-case scenario, if export opportunities are severely hampered, this would be a catastrophic risk for the grain sector, leading to many other problems and risks, e.g., financial and settlement risks, food storage problems. The activity of national potato processing companies, especially starch production, also depend significantly on exports. Although the international food supply is still sufficient, researchers warn of negative effects that are likely to lead to higher food prices (Petetin, 2020). In general, a number of problem areas were identified, which could be exacerbated if the crisis had deepened, as the food industry depended on export markets and imported materials: a lack of storage capacity for finished products and raw materials, and the availability of working capital to purchase inventories of raw materials and meet liabilities in the event of declining revenues. The important resilience principle is that, in the face of shocks, actors of the food chain will develop adequate strategies/responses. Those can be harmful or unsafe responses as well as more 'positive' responses would be those that help participants to predict, adapt flexibly or reduce the impact of shocks (Béné, 2020). In Latvia, arable crop food supply chain companies have overall successfully adapted to the crisis, use the government support opportunities available, if necessary, flexibly reorganise the production process, develop new products and look for alternative sales opportunities.

Conclusions

To increase the sustainability of arable crop food supply chain companies in Latvia, policy makers need to pay attention to the following three areas:

1) mitigating the impacts of the crisis, including prioritising food production and processing, through ensuring the flow of food and raw materials between countries, stimulating domestic consumption and introducing measures to increase exports; improving access to loans during the crisis; improving the availability of services provided by national institutions under the conditions of remote work;
2) in order to compensate for rising costs and declining revenues, the effectiveness and availability of financial support measures already in place need to be improved, yet it is required to cut red tape and increase the flexibility of conditions for receiving government support during the crisis;
3) increasing the resilience of the food industry and caring about growth after the crisis: more stable public policies for business development, access to loans and the willingness of banks to lend to businesses both during and after the crisis, increased protection of domestic goods, support for export-orientated businesses and reduced VAT rates on food products are needed.

The main proposals for food supply chain companies, aimed at alleviating the crisis in the food sector, are to make financial savings for crises, review cost reduction options, review or postpone investment plans to ensure the availability of working capital to overcome the crisis; closely follow what is happening in the industry and markets, look for alternatives to the diversification of cooperation partners, carefully plan production volumes, develop an action plan for emergency situations on the basis of instructions prepared by the responsible institutions, if possible, automate the production process in order to reduce manual labour and consequently both costs and dependence on labour availability as well as assess and increase storage capacity.

References

Asaad, J. (2022, June). *Fixing the 5 Big Problems in the Food Supply Chain.* Retrieved October 15, 2021, from: https://supplychainbeyond.com/5-big-problems-in-the-food-supply-chain/.

Bakalis, S., Valdramidis, V., Argyropoulos, D., Ahrne, L., Chen, J., Cullen, P. J., Cummins, E., Datta, A. K., Emmanouilidis, C., Foster, T., Fryer, P., Gouseti, O., Hospido, A., Knoerzer, K., LeBail, A., Marangoni, A., Rao, P., Schlüter, O., Taoukis, P., Xanathakis, E., & van Impe, J. (2020).

Perspectives from CO+RE: How COVID-19 changed our food systems and food security paradigms. *Curr. Res. in Food Sci.* 3, 166-172. DOI: 10.1016/j.crfs.2020.05.003.

Barman, A., Das, R., & de Kanti, P. (2021). Impact of COVID-19 in Food Supply Chain: Disruptions and Recovery Strategy. *Curr. Res. in Behav. Sci.* 2. DOI: 10.1016/j.crbeha.2021.100017.

Béné, C. (2020). Resilience of local food systems and links to food security – A review of some important concepts in the context of COVID-19 and other shocks. *Food Secur.* 12, 805-822. DOI: 10.1007/s12571-020-01076-1.

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., de Haan, S., Prager, S. D., Talsma, E. F., & Khourya, C. K. (2019). When food systems meet sustainability - Current narratives and implications for actions. *World Dev.* 113, 116-130. DOI: 10.1016/j.worlddev.2018.08.011.

Buldyrev, S. V., Parshani, R., Paul, G., Stanley, H. E., & Havlin, S. (2010). Catastrophic cascade of failures in interdependent networks. *Nat.* 464, 1025-1028. DOI: 10.1038/nature08932.

Colafemmina, D., El Bilali, H., & Capone, R. (2020). Impacts of COVID-19 on food security and food system sustainability. In XI International Scientific Agriculture Symposium „AGROSYM 2020", 8-9 October, 2020 (pp. 925-933). Jahorina: University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia.

Coluccia, B., Agnusdei, G. P., Miglietta, P. P., & de Leo, F. (2021). Effects of COVID-19 on the Italian agri-food supply and value chains. *Food Control,* 123(4). DOI: 10.1016/j.foodcont.2020.107839.

Constas, M., Frankenberger, T. R., & Hoddinott, J. (2014). *Technical Series No. 1 "Resilience measurement principles: Toward an agenda for measurement design"*. Retrieved from: https://www.fsinplatform.org/sites/default/files/paragraphs/documents/FSIN_TechnicalSeries_1.pdf.

Deconinck, K., Avery, E., & Jackson, L. A. (2021). Food Supply Chains and Covid-19: Impacts and Policy Lessons. *EuroChoices.* 19(3), 34-39. DOI: 10.1111/1746-692X.12297.

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security. *Food Secur.* 12, 769-772. DOI: 10.1007/s12571-020-01085-0.

Ericksen, P. J. (2008). Conceptualizing food systems for global environmental change research. *Global Environ. Change.* 18(1), 234-245. DOI: 10.1016/J.GLOENVCHA.2007.09.002.

Ericksen, P. J., Ingram, J. S. I., & Liverman, D. M. (2009). Food security and global environmental change: Emerging challenges. *Environ. Sci. and Policy.* 12(4), 373-377. DOI: org/10.1016/j.envsci.2009.04.007.

Folke, C. (2006). Resilience: the emergence of a perspective for social-ecological systems and analyses. *Global Environ. Change.* 16(3), 253-267. DOI: 10.1016/j.gloenvcha.2006.04.002.

Food security and nutrition: building a global narrative towards 2030 – Executive Summary (2020). Environmental Education Center of Kalamata: Committee on World Food Security, High Level Panel of Experts on Food Security and Nutrition. (15th Report)

Górnaś, P., Grāvīte, I., Grīnberga-Zālīte, G., Ikase, L., Īriste, S., Janmere, L., … Zeipiņa, S. (2021). *Restructuring Local Food Chains and Strengthening Resilience during the Crisis and Post-crisis in Latvia.* Jelgava: Latvia University of Life Sciences and Technologies; Institute of Horticulture. (Report, Part I)

Hobbs, J. E. (2020). Food Supply Chains During the COVID-19 Pandemic. *Can. J. of Agric. Econ.: Special Issue Article 2020.* 68, 171-176, DOI: 10.1111/cjag.12237.

Lamine, C. (2015). Sustainability and Resilience in Agrifood Systems: Reconnecting Agriculture. Food and the Environment. *Sociol. Ruralis.* 55(1). DOI: 10.1111/soru.12061.

Latvia Ministry of Agriculture. (2021). *Agriculture of Latvia 2020*. Riga: Latvia Ministry of Agriculture.

Marsden, T., Banks, J., & Bristow, G. (2000). Food Supply Chain Approaches: Exploring their Role in Rural Development. *Sociol. Ruralis.* 40(4), 424-438. DOI: 10.1111/1467-9523.00158.

Nguyen, H. (2018). *Sustainable food systems - Concept and framework*. Retrieved from: http://www.fao.org/3/ca2079en/CA2079EN.pdf.

Partalidou, M. (2015). Food Miles and Future Scenario for Local Food Systems: an Exploratory Study in Greece. *Agric.* 44(2), 151-157. DOI: 10.5367/oa.2015.0207.

Petetin, L. (2020). The COVID-19 Crisis: An Opportunity to Integrate Food Democracy into Post-Pandemic Food Systems. *Eur. J. of Risk Regulation.* 11(2), 326-336. DOI: 10.1017/err.2020.40.

Renn, O. (2020). The Call for Sustainable and Resilient Policies in the COVID-19 Crisis: How Can They Be Interpreted and Implemented? *Sustainability*. 12, 64-66. DOI: org/10.3390/su12166466.

Savary, S., Akter, S., Almekinders, C., Harris, J., Korsten, L., Rötter, R., Waddington, S., & Watson, D. (2020). Mapping disruption and resilience mechanisms in food systems. *Food Secur.* 12, 695-717. DOI: 10.1007/s12571-020-01093-0.

Serrano, A., & Brooks, A. (2019). Who is Left Behind in Global Food Systems? Local Farmers Failed by Colombia's Avocado Boom. *Environ. and Plan. E: Nat. and Space*. 2(2), 348-367. DOI: 10.1177/2514848619838195.

Schmidhuber, J., Pound, J., & Qiao, B. (2020). COVID-19: Channels of transmission to food and agriculture. Retrieved from: http://www.fao.org/documents/card/en/c/ca8430en/. DOI: 10.4060/ca8430en.

Stephens, E. C., Martin, G., van Wijk, M., Timsina, J., & Snow, V. (2020). Editorial: impacts of COVID-19 on agricultural and food systems worldwide and on progress to the sustainable development goals. *Agric. Syst.* 183. DOI: 10.1016/j.agsy.2020.102873.

The Organisation for Economic Co-operation and Development. (2020, April). *COVID-19 and the food and agriculture sector: Issues and policy responses*. Retrieved September 20, 2021, from: https://www.oecd.org/coronavirus/policy-responses/covid-19-and-the-food-and-agriculture-sector-issues-and-policy-responses-a23f764b/. DOI: 10.4060/ca8464en.

The Organisation for Economic Co-operation and Development. (2020, June). *COVID-19 and international trade: Issues and actions*. Retrieved October 17, 2021, from: https://www.oecd.org/coronavirus/policy-responses/covid-19-and-international-trade-issues-and-actions-494da2fa/. DOI: org/10.1787/5b0fd8cd-en.

The Organisation for Economic Co-operation and Development. (2020, July). *Food Supply Chains and COVID-19: Impacts and Policy Lessons.* Retrieved October 1, 2021, from: https://www.oecd.org/coronavirus/policy-responses/food-supply-chains-and-covid-19-impacts-and-policy-lessons-71b57aea/. DOI: 10.4060/ca8833en.

Umar, M., Wilson, M., & Heyl, J. (2017). Food Network Resilience Against Natural Disasters: A Conceptual Framework. *SAGE Open: Business and Management*, 7(3). DOI: 10.1177/2158244017717570.

Weersink, A., von Massow, M., Bannon, N., Ifft, J., Maples, J., McEwan, K., McKendree, M. G. S., Nicholson, C., Novakovic, A., Rangarajan, A., Richards, T., Rickard, B., Rude, J., Schipanski, M., Schnitkey, G., Schulz, L., Schuurman, D., Schwartzkopf-Genswein, K., Stephenson, M., Thompson, J., & Wood, K. (2021). COVID-19 and the agri-food system in the United States and Canada. *Agric. Syst*. 188. DOI: 10.1016/j.agsy.2020.103039.

Why export restrictions should not be a response to COVID-19: Learning lessons from experience with rice in Asia and the Pacific (2020). Retrieved from: http://www.fao.org/3/ca9362en/CA9362EN.pdf. DOI: 10.4060/ca9362en.

Central Statistical Bureau of Latvia. (2022). *Area under agricultural crops, total yield and average productivity in regions 1990-2020*. Retrieved October 10, 2021, from: https://data.stat.gov.lv/pxweb/lv/OSP_PUB/START__NOZ__LA__LAG/LAG030/.

Acknowledgement

The paper was supported by the National Research Programme "Towards the Post-pandemic Recovery: Economic, Political and Legal Framework for Preservation of Latvia's Growth Potential and Increasing Competitiveness" (reCOVery-LV), Project Agreement: VPP-COVID-2020/1-0010.