THE EFFECT OF THE COVID-19 PANDEMIC ON FOOD SUPPLY CHAIN DISRUPTION IN DEVELOPED COUNTRIES

تأثير وباء كورونا علي اضطراب سلاسل الامداد الغذائية في الدول المتقدمة

إعداد

Eman Hamdy Abd EL-Kader

إشراف

DR. Khaled EL-Sakty

ملخص البحث:

هدف البحث: تصف هذه الدراسة تأثيرات فيروس كورونا الجديد على عملية سلسلة التوريد لصناعة الأغذية في الدول المتقدمة

منهجية البحث: تم إجراء تحليل على 15 مقالات صناعية وتم تصنيفها إلى موضوعين رئيسيين: تأثير كل مرحلة ، والتأثيرات العامة على جميع المراحل ، وكل منها مقسم إلى مواضيع إضافية. يتم دعم المراجعة المنهجية بشكل أكبر من خلال المقابلات الشخصية مع المتخصصين في الصناعة.

نتائج البحث: تُظهر النتائج أن الشركات تتجه نحو التوطين ، والتركيز على مخاطر الموردين من الدرجة الأولى ، والتجارة الإلكترونية ، وتغيير سياسات المخزون الخاصة بهم ، وتقييم مصادر التوريد البديلة لإدارة الاضطرابات التي تسببت في عملياتهم التجارية وسط تفشي COVID-19.

توصيات البحث: يوصى بإيلاء المزيد من الاهتمام لحماية الإمدادات الغذائية من الاضطرابات وتعزيز تصميم سلسلة التوريد الغذائي في المستقبل. كما ينبغي تحسين المرونة في سلسلة الإمداد الغذائي في المستقبل. يمكن لشركات سلسلة التوريد استخدام الإجراءات المضادة الواردة في هذه الدراسة للتخفيف من تأثير COVID-19 وتحقيق أقصى استفادة من هذا الوباء.

الكلمات الرئيسية: COVID-19 ، سلسلة التوريد ، اللوجستيات ، سلسلة الأمداد الغذائية

Abstract

Significance: This study represents a pioneering effort to unveil the consequences and effects of COVID-19 on the food industry in developed countries.

Research Aim: This study describes the influences of the novel Coronavirus on the supply chain process of the food industry in developed countries.

Research Methodology: An analysis was conducted on ١5 industry articles and categorized into two major themes: the effect of each stage, and the general effects on all stages, each is further subdivided into additional themes. The systematic review is further supported by international case studies.

Research Findings: Results show that firms are moving to localization, focusing on tier-1 supplier risk, e-commerce and changing their inventory policies, and evaluating alternative sources of supply to manage disruptions caused to their business operations amid the COVID-19 outbreak.

Research Recommendations: It's recommended to pay more attention to protect the food supply against disruptions and to strengthen the design of the food supply chain in the future. Also, resilience in the food supply chain should be improved in the future. Supply chain firms can use the countermeasures provided in this study to mitigate the impact of COVID-19 and make the best out of this pandemic.

Keywords: COVID-19, Supply chain, Logistics, Food supply chain

1. Introduction:

Over time, the world has faced many diseases and unanticipated catastrophic events that are deeply affecting the living way. Such events are usually termed disruptions with varying intensity. The impact of such outbreaks is more severe because of their distinguished features including demand and supply, long-term disruption, and impacts on the infrastructure (Ivanov, 2020). In December 2019, an unmatched outbreak of unknown pneumonia emerged in Wuhan, China. This was later announced by the World Health Organization (WHO) as a new coronavirus disease (COVID-19). Governments have responded rapidly to reduce the dual crises of public health & economic fall that the pandemic has caused. Borders have been closed, paralyzing global trade and migration, billions of people have been socially isolated, changing work patterns, production & consumption, and many people have been laid off and required economic motivation at historically unseen levels (Evenett, 2019). Unlike many extreme events (earthquakes, wildfires, etc.) the impacts of COVID-19 are geographically spread in their nature and have shown the weakness of the global economy in physical & human terms. Now, COVID-19 makes governments & firms strengthen their capacity to cope with extended economic self-isolation periods (Hobbs, 2020). Since 1980, the world's manufacturing production has been more structured to be known as global supply chains (or global value chains). Raw materials and

intermediate goods are now frequently shipped around the world many times before final products are exported to final consumers. China has become the most vital link in many global supply chains as a large customer of global cargo, a primary manufacturer and assembler, and a major consumer marketplace (Lin, 2020). While it is still too early to rightly quantify the effects of supply chain disruptions provoked by the pandemic. COVID-19 could be the straw that breaks the camel's back of economic globalization. This research has addressed the following problem: "To study how the COVID-19 pandemic is disturbing the global food supply chain and how it responded to the pandemic in developed countries".

2. Literature Review

A crisis is an unpredictable event that has potentially negative effects on a business's ongoing growth, operations, reputation, profitability & survival (Rustici, 2020). Crises can arise internally from management failures or externally from the environment. (Hobbs, 2020) stated that pandemic outbreaks create a demand-side impact on food supply chains, including the consumer's panic buying behavior. COVID-19 has put production on hold and the demand has fallen for specific products. Especially, the food industry has been reduced by about 80–100% in sales due to the lockdown (Sheth, 2020). The inflow of cash for retailers has suddenly stopped, which led to a slowdown in cash rotation except for suppliers with essentials

(Fantozzi, 2020). Laborers were stuck in lockdown due to this pandemic outbreak. This shortage has created a disaster in goods production & delivery of finished goods. In times of crisis, the issue of a safe supply of necessities and ensuring food security became the most important (Ivanov, 2020). (Kilpatrick, 2020) suggests long-term political measures to ease recovery and growth. Supply chain disruptions are defined as "unplanned & unanticipated events that disrupt the normal flow of goods and material in a supply chain and, as a consequence, expose firms to operational & financial risks" (Fantozzi, 2020). A disruption can affect the other supply chain elements (upstream or downstream) functionality. A study discussed that the effect of COVID-19 is an enormous disruption to global value chain management (Ivanov, 2020). This pandemic has sharply reduced the exchange rates, and commodity & energy prices of developing economies (Handfield et al., 2020).

As the food supply chains are becoming increasingly complex because of globalization, the risk mitigation measurements have to be proactive for effective operations management (Sheth, 2020). Globalization is the thickening of cross-national interactions that promote the global integration of social, economic, ecological, political & technological processes on global or local levels. New research suggests that COVID-19 is influencing trade, financial flows, business structures & strategies (Enderwick & Buckley, 2020). Since the 1980s, many

governments reduced tariff protection & subsidies, privatized public assets & promoted foreign direct investment (Dhir et al., 2020). Global supply chains have facilitated an important shift in manufacturing with workers in developing countries that produced about 50% of the value of global manufacturing exports by 2015 (WTO, 2020). Multinationals rely on 2 methods for accessing global supply chains. First is foreign direct investment via subsidiaries. The second is signing different contracts with suppliers. Most of the value-added preproduction (R&D and design) & postproduction (marketing, distribution & logistics) segments are retained in developed countries with developing countries specialize in the lower value-added mass production segment (Kumar et al, 2021). Empirical signals of the production across borders involve "high cross-border mergers & acquisitions; rise multinational ownership of capital shares & spread of cross-border strategic alliances of all sorts" (Ivanov, 2020). The global export of manufacturing came from China, which increased from 8% in 2003 to 19% in 2018. (Free & Hecimovic, 2020). Now, China produces about 30% of manufactured goods (Rustici, 2020). Now, the annual sales of multinational companies represent 50% of the global GDP (Lin, 2020). Uncertainty & high risks of COVID-19 highlight the need to evaluate its lasting effects on the food supply. It has become a challenge for supply chain management at all levels. Little

business research has shown the potential effects of global challenges like COVID-19, so further research is needed.

3. Research Model

3.1 Research Variables:

This research aims at describing the following simple hypothesis:

- Independent variable: COVID-19
- Dependent variable: Food supply chain

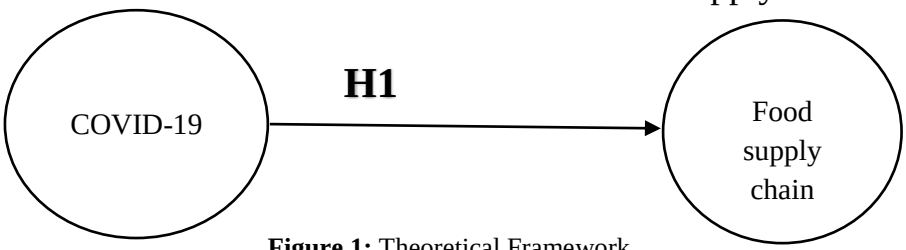

Figure 1: Theoretical Framework

Research Hypothesis

Previous research has proposed that the nature of cooperation & integration in the global economy are shaped by crisis events such as the world wars, the great depression & the global financial crisis. Now, COVID-19 can shift debates on the global food supply chain and has the potential to strengthen & reverse processes. This study represents an effort to show the consequences of COVID-19 on the food supply chain disruption. This study developed the below hypothesis:

- **H1: The COVID-19 pandemic negatively affected the food supply chain in developed countries.**

4 Research Objectives:

- To study the effect of COVID-19 on the global food supply chain.
- To discuss how food supply chains can be viewed in the post-pandemic era in developed countries.

5 Research Methods:

This study is a descriptive study that was made to describe the correlation between COVID-19 and food supply chain disruption, which used qualitative methods:

- Qualitative methods: Semi-structured interviews were used to allow for open-ended responses from participants for more information & to allow them to open up to sensitive issues in much detail. Also, 2 case studies were used.

5.1 Data Collection Techniques:

- Secondary data are important for local, public & semi-public organizations to reach objectives correctly. Some specific variables are identified linking the domains, which have been collected by official international organizations like the UN websites, and social media.

5.2 Sample size & Data Interpretation:

A systematic review is a comprehensive summary that attempts to identify, select and synthesize all related evidence to provide an unbiased overview of the selected topic (Norris et al, 2021). A systematic review was selected for this study to understand the multitude of responses from global food firms during the initial

countermeasures of COVID-19, as two major countries were selected China & Canada, due to their prevalence in the food industry. All articles were reviewed and selected based on their applicability to the aim of the research. Applicability was determined either from the title of the article or from a precursory scan of the article's contents, so a total of 60 articles were collected. 45 were removed from the analysis because they focused on the overall effects on the industry, and the other 15 articles were reviewed again. Then an interview request was sent to industry professionals to provide a deeper understanding of the operational changes and the thought processes behind the decisions, and 3 responses were received.

6 Supply chain & its disruption:

Crisis events often have negative impacts on businesses through reducing demand and revenue, supply & resource shortages, increasing costs & disruption of normal operations & employee layoffs. The supply chain is the network of organizations that are connected upstream and downstream by implementing various processes & activities to deliver a product or service to the consumer (Alsuwailem et al, 2021). Supply chain disruptions are defined as "unplanned and unanticipated events that disrupt the normal flow of goods and material in a supply chain & as a consequence, expose firms to operational & financial risks" (Yang. Y et al, 2020). Crisis events reported in the food industry include epidemic diseases, such as SARS and the avian flu,

financial & economic crises & terrorist events, such as the 9/11 attacks (Yang. Y et al, 2020). About 94% of Fortune 1000 firms have undergone COVID-19-driven disruption (Fortune, 2020). The impact of COVID-19 creates a sequential effect that extends through many sectors (buyers, distributors, suppliers) in the supply chain. There has never been such a period when supply chains were under massive pressure because of lockdowns & policies introduced by governments worldwide restricting the free flow of goods and services (Ivanov, 2020). Businesses had to suspend the raw materials' flow because of the country-wide lockdown, which has led to a big issue for manufacturers and their logistics departments.

As industries become more complex and the market more mature, a transfer from a traditional stage to a transitional stage competition can be noted. The food industry, in particular, has encountered around an 80–100% cut down in sales because of the lockdown (Magzter, 2020). COVID-19 has paused production and the demand has fallen for specific products. The inflow of cash for retailers has suddenly stopped, which led to a slowdown in the cash rotation except for the suppliers with essentials. But some recent studies argue that COVID-19 is a motivation for firms to reconsider their existing supply chain strategies and short-term procedures can be executed to respond to or reduce the immediate challenges (Ivanov & Dolgui, 2020; Ivanov and Das, 2020). (Ivanov, 2020) said that firms may face the supply

chain disruptions caused by COVID-19 by concentrating on tier 1 suppliers only. As firms should work with them to understand the inventory level and production orders to respond to any changes and adopt new digital approaches to clarify the supplier network to gain visibility of the major components' supply chain. Also, businesses need to find substitute sources of supply such as working with secondary suppliers to determine additional inventory and capacity (Ivanov and Dolghi, 2020).

6.1Food supply chain:

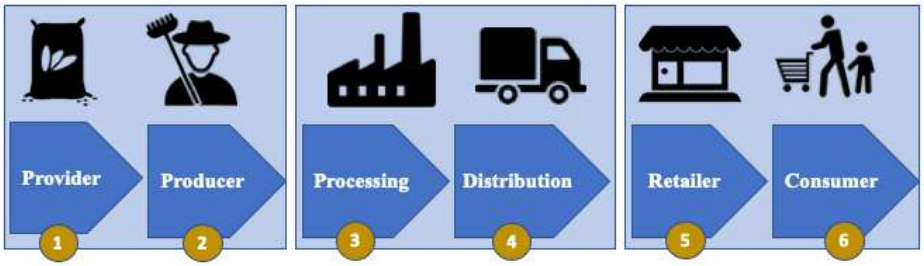

Figure 2: Food supply chain, source: (Kamilaris, 2019)

A food supply chain is known as "a series of links and inter-dependencies from farms to food consumer plates, embracing a wide range of disciplines" (Alsuwailem et al, 2021). Thus, food proceeds from food creators to consumers through the following 6 stages: providers, producers, processing, allocation, retailing & consumption. The food industry is a collection of contextual & evolving social practices in social, cultural & political terms, including food production & consumption (Alsuwailem et al, 2021). Many external factors can affect food sales: national

economic conditions (e.g., GDP, unemployment rate & interest rate); national social-demographic characteristics (e.g., population); weather; time (of a day/ week/ year); events; government policies; and various crises (e.g., diseases) (Huang, 2021). Food supply chains consist of many interdependent procedures and operations, such as supplier, distribution center, food processing & consumer handling to deliver food products from suppliers to the end customer. Food production usually could be limited by low technology levels. So, digital innovations in the food industry can be the link between global innovations & the food industry. To assure food security, food production continuity & the availability of ingredients are vital (Alsuwailem et al, 2021). Customer demand analysis is critical for the food service industry, given the perishability of related products and services. Forecasting trends and exploring the characteristics that affect consumer demand can inform strategic planning and marketing. Such information can facilitate food service-related policymaking and evaluation among governments & other public sectors.

The food industry, from farms to shops is one of the industries that have to continue its operations because of the necessity to serve the nations and fulfill basic needs. From a strategic perspective, the changes in the food industry have been one of the longstanding interests of the empirical literature highlighting various stages of maturity & complexity in the competition (Barrett et al., 2020). This raises competition in both upstream

(i.e., cargo procurement) and downstream (e.g., retailing) segments of the supply chain (Huang, 2021). Value creation in the food industry is known as "the ability to economically add value to a product by changing its characteristics to meet the market's requests via 2 main activities: innovation & coordination" (Barrett et al., 2020). Innovation means concentrating on improving current processes, products, procedures, and services or creating new ones. This occurs usually, in markets where innovation defines the success or failure of a product (Barrett et al., 2020). Coordination includes the arrangements or agreements between firms about some activities and/or initiatives in the value chain. The food sector hasn't been considered in the literature regarding the impacts of the main crisis, as it has been traditionally accounted for its characteristics, and can absorb and simplify external shocks (Barrett et al., 2020). Food supply chains are examples of networks that can contain the economic impacts of the current pandemic due to their ability to quickly adapt to dramatic environmental changes to react to unprecedented shifts in supply and demand (Yang, 2020).

6.2Food supply chain & COVID-19:

The virus has spread fast and reached the whole world in less than a year of its first outbreak. Turning the whole globe on its head, it was expected that this mortal virus may be as contagious economically as it is medically (Handfield et al., 2020) requiring

collective action to beat it. Food supply chains and food industries are in a danger due to the global crisis as COVID-19 has impacted the food business sector. There is a challenge in the post-COVID-19 crisis to provide food & services to the citizens through food supply chain systems & re-strategize the supply chain (Yang, 2021). During pandemics, it is difficult to deal with the demands of consumers, solve food production problems due to lockdowns, work with minimum labor, and avoid transportation disruptions (Alsuwailem et al, 2021). It was expected that COVID-19 will adversely affect the food supply chains from the production point to the consumption point due to the restrictions imposed on transportation that will challenge the food supply chains and negatively affect both the producers & consumers (FAO, 2020). There has already been a continuous challenge in rising market efficiencies for different agrifoods in emerging economies (e.g., Alsuwailem et al, 2021). The pandemic's destructive impact has been more damaging to less developed countries & weak and marginalized communities (Shadmi et al., 2020). The pandemic resulted in fewer commercial passenger flights and higher freight costs because of lower trade volumes since most of the planes were stopped, which made barriers to exporting perishable food products like fish, vegetables & fruits (OECD, 2020). COVID-19 has severely affected the food sector through new buying behavior, raising the price of inputs, raising inputs price & the lack of food. The

effects are expected to be greater as compared to any other outbreaks such as 2003 SARS (Barrett et al., 2020). In Brazil, food price is different among regions affected by COVID-19. The tomato price has raised by 66.91% & of onions by 101.53%. Cancellation of passenger flights & travel bans has limited the availability of air cargo while urgent shipping of essential goods has increased demand resulting in rises in the price of air cargo (compared to October 2019, air freight costs raised by 30% between China & North America and by +60% on some Europe-North America routes) (Huang et al, 2021) with a raise in the delivery times. Critical shipping ports reported drops in cargo between 10%-20% in Feb 2020 (Dorcheh et al, 2020). Over 50 countries have changed port protocols (i.e., port closure & extra documentation requirements. Many shipping containers were in Chinese ports, and restrictions on movement have led to their shortage & a rise in their price. Lockdowns affect the food import & availability of labor to unload ships at ports (in countries less automated) or raised costs due to protective measures for workers. The production process has been consolidated globally in countries like China or other low-cost economies such as India. COVID-19 has threatened the firm's continuity plans. There is a huge disruption in tier 1 suppliers, and they are suffering to rebalance their short-term sourcing decision. Firms should work on an approach that will help them administrate the impact of COVID-19. The procurement teams are working hard,

but the danger is pressing and there is an opportunity that the contracts would be delayed or terminated. Because contractors and supplying firms couldn't fulfill their contract requirements due to the shutdowns (Shadmi et al., 2020).

7. Case studies:

7.1 China case study of hog:

Reason: A simulation study was made by (Wang et al, 2020) to analyze the effect of short-term supply chain disruptions from COVID-19 on China's hog market. The dynamic cycle of the hog contains 4 stages: hog production, pork inventory, international trade & pork consumption. The below variables have been used:

- 1st variable: COVID-19
- 2nd variable: the hog markets
- 3rd variable. live hog price
- 4th variable: consumption demand
- 5th variable: breeding stock
- 6th variable: net import
- 7th variable: pork inventory (demand gap)

Results: Chinese hog market dynamics have been simulated for 5 years from August 2019 - July 2024 as it's the time that the hog market started to rise and the concern of food security emerged.

A. **The baseline scenario:** reflects the market situation of tight hog supply before COVID-19. The first hog price peak was forecasted to reach +38.6 RMB/kg in August 2020 due to a reduction in pork production. Breeding stock was expected to

grow up until April 2021. Consumption demand was reduced after the price raises but benefits from an increased pork import. Net pork import increased with hog price, which arrived at a peak import level in November 2020 at 0.39m T. while net import reduced to its lowest volume of 0.17mT. Market dynamics were expected to reach a peak hog price of 36.9 RMB/kg in early 2024. It was forecasted that the hog market will be in a tight supply status. So, the loss in hog farm productivity can't recover soon. Hog price raised from 22 RMB/kg-35 RMB/kg during the August–December period. Pork imports also raised as expected to above 0.3mT.

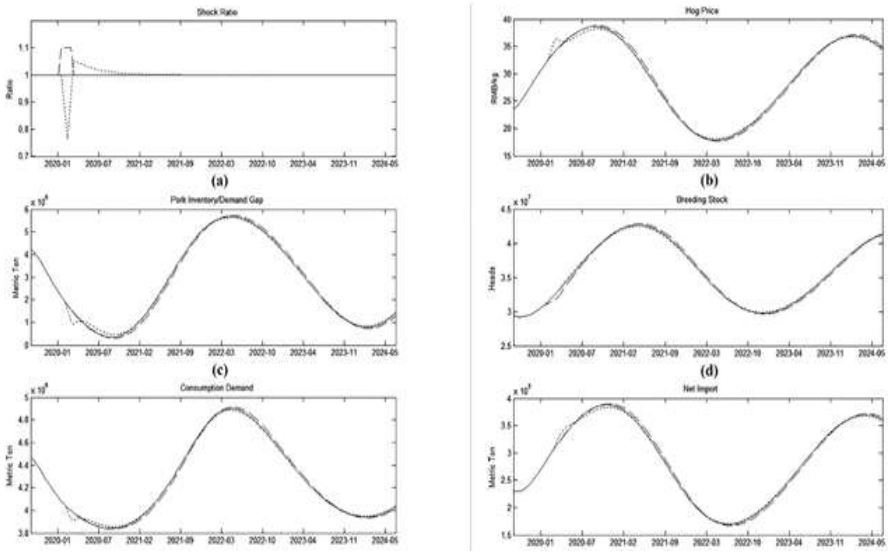

Figure 3: Supply chain disruptions: corn and market hog transportation, source: (Wang et al, 2020)

B. **Corn shortage and price jump scenario:** Supply chain disruption from feed transportation is the main concern. A feed supply has suddenly stopped for some livestock farms due to traffic restrictions to mitigate the spread of COVID-19. In the sample period, corn price has been stable with the max price change of less than 5% from 2 RMB/kg. The hog price peak is expected to be 38.8 RMB/kg in August 2020, 0.2 RMB/kg higher than the baseline. The price trough is expected to be 17.7 RMB/kg in March 2022, 0.2 RMB/kg lower than the baseline. The wider range of hog price variation leads to a widener range of breeding stocks variation by 0.1m heads to the baseline. Pork consumption demand marginally varied from the baseline by a max of 4981 T/month. Also, Pork imports had a slightly wider change by a max of 702 T/month. Thus, the rising corn price because of the temporary scarcity led to a rise in the hog price peak in the short run, but the magnitude is small.

C. **Market hog transportation disruption scenario:** Same as the feed supply, the market hog transportation to packing plants has been stopped due to traffic restrictions. Packing plants had to raise the buying price for hogs or close because of the lack of accessible hog supply. In Feb 2020, the slaughter volume of inspected packing plants was reduced by 36% over a year ago based on a 17% lower hog inventory. The Live hog price was set at 36.5 RMB/kg in Feb 2020 to

maintain production operations. When transportation was restored, hog prices were reduced to a low of 36 RMB/kg in March & April because packing plants increased production to absorb accumulated hogs then the market returned to the baseline track by July 2020. But due to the earlier disruption, the hog price peak is expected to reach 38.2 RMB/kg, 0.4 RMB/kg lower than the baseline. The lower the hog price, the lower pork import & higher domestic prices.

D. **Delay in breeding stock replacement scenario:** For hog farms that wanted to add a new breeding herd, transport impediments could delay this process. Same to the effect of the corn price jump, the capacity of the hog price cycle is extended wider by 0.1 RMB/kg. The breeding stock building process is kindly delayed during March–April but a max of 0.8m heads. But it recovered in the second half of 2020 when the hog price got higher. The breeding stock peak arrived at a higher level of 42.8m heads, up by 0.1m heads than the baseline almost at the same time.

E. **Delay in pork import scenario:** international shipping disruptions created the import delay time to double to 4 months and could be extended for a longer period. Net pork import reduced in Feb and was below the baseline through April. After shipping amplitude got back to normal, there will be a recovery starting from May over a half-million T, then declined because more imports created pressure on hog

prices. Import volume became eventually equal to the baseline level in November 2020. From May-November, the hog prices were lower than the baseline by an average of 0.5 RMB/kg due to the higher pork import during this period.

F. **Combination of all supply chain disruptions:** The 4 disruption scenarios could be happened together instead of independently. For hog prices, the clear difference from the baseline was between Feb and September 2020, when the market could be through supply chain disruptions. Due to the mixed effect of disruptions in market hog transport & import shipments, the hog price raised to a short-term peak of 36 RMB/kg. Then of slaughter volume & import increase, the hog price adapted to a temporary low of 35.5 RMB/kg before rebounding higher to 38.2 RMB/kg after the normal cycle. When the hog price arrives at the lowest at 17.9 RMB/kg in April 2022, it almost combines with the baseline results. Pork consumption demand changed during the disruption & then stayed below the baseline level by an average of 20,000 T/monthly.

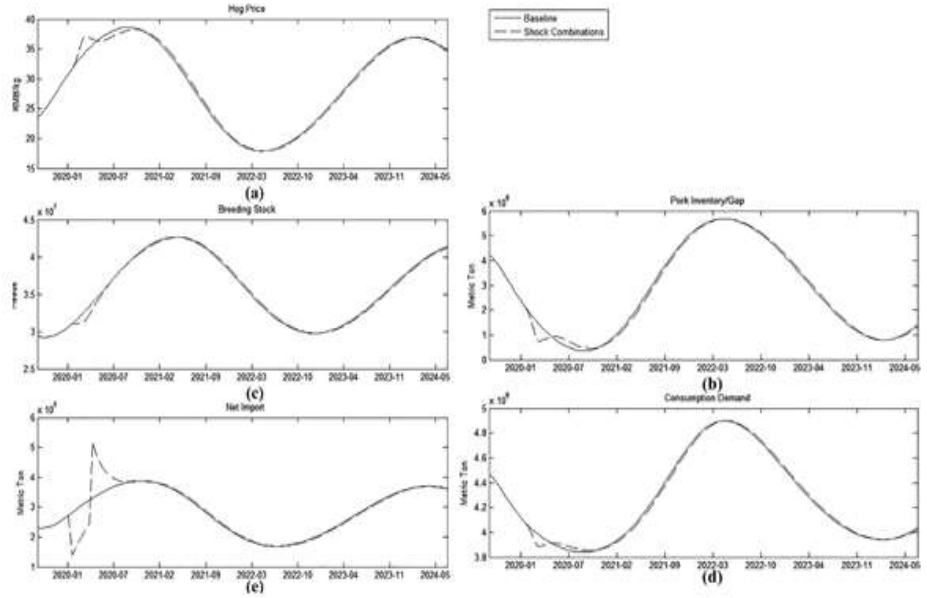

Figure 4: Combined supply chain disruptions, source: (Wang et al, 2020)

7.2 Canada case study of lobster:

Reason: A simulation study was made by (Huang et al, 2021) to analyze how COVID-19 has adversely disrupted lobster supply chains and their sustainability in Nova Scotia, Canada from 4 perspectives:

- 1st variable: COVID-19
- 2nd variable: Production-inventory dynamics
- 3rd variable: Customer performance
- 4th variable: Financial performance
- 5th variable: Lead-time performance

Results: Suppliers of lobster are in Halifax and Digby, and they are the 2 top-volume lobster producers in Nova Scotia. Customers used to order products from factories or food services every 5 days that were located in Montreal, Vancouver, Edmonton & Toronto. Suppliers utilize airplanes to deliver their live lobster to distribution centers, and distribution centers and factories utilize trucks to deliver products & most of the orders from factories are shipped by FedEx (Lobster Canada, 2020).

A. **Production-Inventory Dynamics:** Previously, customers' orders' were often between 4-80 lbs/order before March 2020. During the pandemic, demand decreased by 40%, as most lobsters are sold at restaurants. Inventories for suppliers are checked every 60 days, and inventory DC & factories are checked every 30 days. But they stop producing & checking between day 75 - day 120 because of the pandemic. The backlog problem for the live lobster industry led to a reduction in the stock of lobster. Suppliers couldn't sell the same amount of lobster as before, so the inventory for live lobster kept raising especially in the short run from day 150 - day 300. But the extra backlog began to fall as the pandemic's effect becomes lower & gradually would get back to the normal level in the long run. The disruption will continue for at least one year. The price crash will make adverse impacts on each stage.

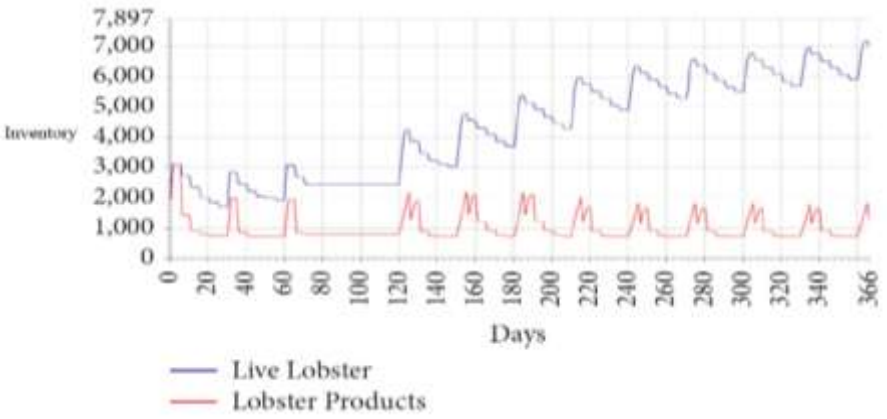

Figure 5: Available inventory including backlog (lbs.), source: (Huang et al., 2021)

B. **Customer performance:** Trucks often took 2-3 days to deliver live lobster to the DC and took 1-2 days to provide live lobster to factories. Customers were getting their products within 2 days before March 15th. After March 15th, all lead-time orders would take longer & extend between 2-3 days due to the shutdowns. But, the forecasted lead time for customers was only 3 days. The extended delivery time adversely affects the ELT (expected lead time) service level, which is the ratio of products delivered on time to the overall number of products shipped. As the pandemic began, manufacturers closed and stopped delivering orders to customers, but it eventually raised after day 130 as the pandemic's impact became lighter.

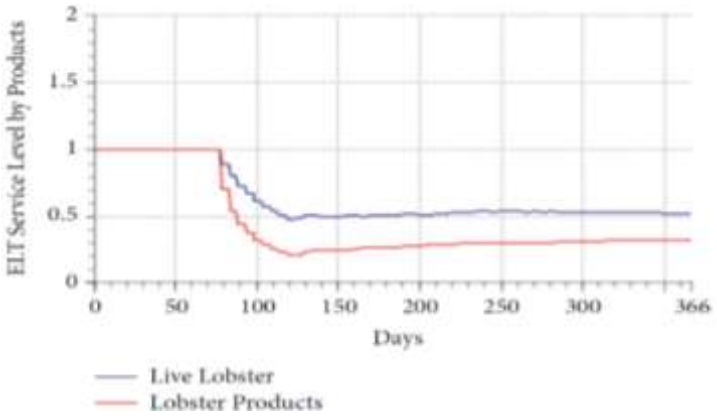

Figure 6: ELT service level by-products (per product), Source: (Huang et al., 2021)

C. **Financial Performance:** The lobster industry can make profits during the pandemic since the blue column is above 0. The products' price is rising eventually yearly by a minimal amount. Additionally, manufacturing and DCs split the demand equally to each of the available sources, which at the same time supply the customers. The selling price of live lobsters from suppliers to DC was about USD 6.5/lbs, and from DC to factories was about USD 9.0–9.5/lbs & from factories (both live lobster & lobster-related products) to the customer USD 10–12/lbs. The outbound processing cost is the most expensive process in the supply chain.

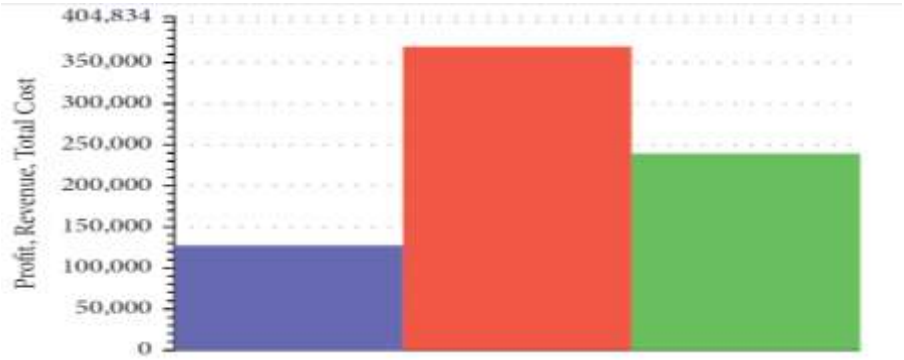

Figure 7: Profit, revenue & total cost chart. Blue/profit; Red/revenue; Green/total cost, (Huang et al., 2021)

Figure 8: Product and price flows, source: (Huang et al., 2021)

D. **Lead time performance:** Before day 120, each factory's mean lead time was stable at around 1.5 days however, after the pandemic, the mean lead time was almost 3 days (doubled) for each factory. But it returned to be stable after day 220. Compared with other factories, the lead time for the Toronto factory was the highest as approached 60 days on day 300, which is double the lead time before day 120. But the lead time for Edmonton has been impacted by the

pandemic the least. The long lead time leads to a decline in demand.

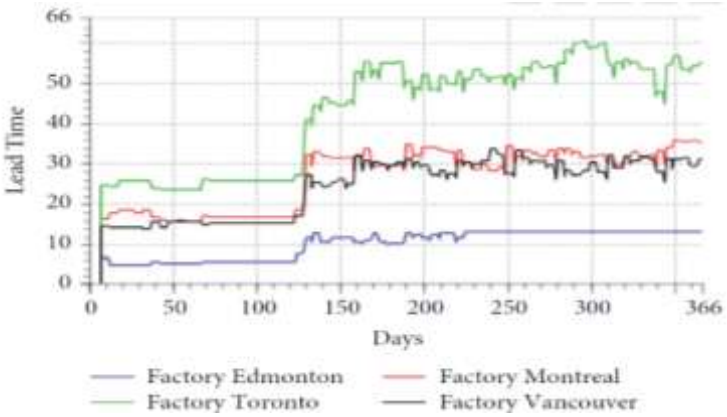

Figure 9: Lead times for different factories, (Huang et al., 2021)

8. Discussion:

Food firms acknowledge that the future of food processing will be more and more digitalized and investments in the production processes are vital to decrease production costs and raise the traceability of the products which are the main elements for competition in the food industry (Bargoni, et al, 2022). Reviewing current strategies could be helpful for governments to create mechanisms because of the entering of multinationals in the competitive arena, less oriented to local communities but more oriented to supply chain efficiency (Bargoni et al, 2022). Policy responses related to the food sectors should be agile and flexible to adapt to the rapidly changing criteria of an uncertain event, such as a pandemic like COVID-19 (Bargoni et al, 2022).

It's critical to concentrate on long-term strategies (e.g., the food sector should be excluded from travel restrictions) to be well-prepared for or avoid other destructive disruptions to the food supply chains in the future. Sustaining food consumption or falling food price volatility should be focused on by activating plans like consumption campaigns' promotions & supporting food distribution by both private & public sectors. Also, profiteering behaviors, such as price gouging & unfair trade practices, should be traced or prosecuted (Barrett, 2020). There were changes in how consumers buy and interact with food due to the pandemic. It has been suggested to apply the below policy measures to assure the proper working of the food supply chain in times of pandemic:

1) Conditional transport should be allowed for staff of food supply chain firms and assure the proper working of the whole chain. The state & the firms in the sector should ensure the suitable protocols to reactivate that sector's economy. Firms should ensure employees who prepare food are applying hygiene control.
2) Firms should manage their processes better by automating their product sales processes by developing applications to decrease product delivery time & production times and avoid order delays. But for SMEs or those that couldn't afford it, governmental support is vital to reach this.

3) In many developing countries, many foods consumed are produced locally, so the state must ensure all supply chain agents' correct operating. The goods transferred directly to the markets must be assured to avoid shortages & price speculation in case of transport restrictions.
4) The managers in the food supply chain must identify an action plan regarding the firm's strategic planning to adequately manage the firm's operations in times of risk, maintaining contact with suppliers & customers, which will permit them to better manage with more resilience.
5) Also, the managers should utilize technologies that permit them to improve the production process; this will improve the firm benefits and integration into the food supply chain.

9. Conclusion, recommendations, and future work:

9.1 Conclusion:

There is a lack of appropriate understanding regarding the consequences of the pandemic on the food supply chain in developed countries facing COVID-19, thus this study tried to fill this gap. The supply chain management literature declared how COVID-19 affects food production & consumer and how food supply chains should reconfigure themselves to decrease the effect of such disruptive events. More agile food supply chains are the strongest networks that can deal with the global pandemic. It was provided to the supply chain managers with clear guidelines on the ideal profile to create a successful food network, facilitate the management of potential

issues & reduce the effect of risky situations such as COVID-19. For more unstructured actors in food networks (e.g., farmers), identifying more formal and adaptable procedures in managing their processes and investing in rising the adoption of technological support. For more structured actors (i.e., producers), creating contingency plans, making elaborate structure analyzes of risk sources, investing in advanced technologies &applying training initiatives to prepare the firm for possible changes. It has been found that COVID-19 affected negatively the local and global food supply chain as it made changes, which weren't managed correctly.

9.2 Recommendations:

The research shows the effects and the responses of the food firms in a specific situation (COVID-19). The reaction to other events not tied to a global pandemic could affect the industry differently and might show other reactions of the firms. It's recommended that the food firms should adjust their supply chain regarding the changing pattern of demand & enhance the market share

An investment in a more flexible system internally & across the supply chain is recommended to keep the firm a step ahead of any future disruption that may happen. The preferences of customers are always changing, but the shift toward e-commerce is important.

The current crisis could speed up the changes mainly, which may create challenges for local authorities to support SMEs and motivate their lifelong learning. Thus, it's recommended that

educational institutions offer tailored education and training programs for entrepreneurship.

9.3 Future works:

The sample size of food suppliers is too small to conduct a deeper. Hence, it's recommended that future studies collect more data on various stages of the food supply chain, and also can be done on the same subject matter by extending the sample framework.

Future research could also study how the return to normal could affect the strategic position of the food firms. Since there is no widespread literature on pandemics outside of SARS, COVID-19 studies will guide comprehension and forecast the potential of shock and crisis research.

Future studies are needed to show its medium & long-term impacts on the food supply chain & related activities (e.g., food shopping/sourcing, consumption, preparation, wastage) and on nutrition security.

References:

1. Alsuwailem, A. A et al, (2021), Impacts of COVID-19 on the Food Supply Chain: A Case Study on Saudi Arabia, MDPI (online), https://www.mdpi.com/2071-1050/14/1/254, [accessed on 3rd May 2022]
2. Bargoni, A. et al, (2022), "Competitive strategies in the agri-food industry in Italy during the COVID-19 pandemic: an application of K-means cluster analysis", British Food Journal (online), https://www.emerald.com/insight/content/doi/10.1108/BFJ-07-2021-0738/full/html, [accessed on 27th May 2022]
3. Barrett, C.B. et al, (2020), "Agrifood value chain revolutions in low- and middle-income countries", *Journal of Economic Literature*, Vol. 58, pp. 1-67.
4. Branicki, L. et al, (2020), "Towards crisis protection(ism)? COVID-19 and selective de-globalization", *critical perspectives on international business*, Vol.17 No.2, pp.230-251
5. Butt. A.S., (2021), "Understanding the implications of pandemic outbreaks on supply chains: an exploratory study of the effects caused by COVID-19 across 4 South Asian countries & steps taken by firms to address the disruptions", International Journal of Physical Distribution & Logistics Management, https://www.emerald.com/insight/content/doi/10.1108/IJPDLM-08-2020-0281/full/html, [accessed on 5th March 2022]
6. Deloitte, (2020), "Combating COVID-19 with resilience", https://www2.deloitte.com/hr/en/pages/about-deloitte/topics/combating-covid-19-with-resilience.html, [accessed on 14th January 2022]
7. Dhir, A. et al, (2020), "Food waste in hospitality and food services: a systematic literature review & framework development approach", *Journal of Cleaner Production*, Vol.270, 122861.

8. Ding. L & Jiang. C, (2020), Restaurant proactive philanthropic activities and customer loyalty: a scenario-based study during the COVID-19 pandemic period", *International Hospitality Review*, Vol. 35 No. 2, pp. 260-279.
9. Enderwick, P. and Buckley, P.J. (2020), "Rising regionalization: will the post-COVID-19 world see a retreat from globalization?", Transnational Corporations, Vol. 27 No. 2.
10. Evenett, S.J. (2019), "Protectionism, state discrimination, and international business since the onset of the global financial crisis", *Journal of International Business Policy*, Vol.2 No.1, pp.9-36.
11. Fantozzi, J. (2020), Starbucks Donates $10 Million in Grants to Employees in Need during Coronavirus Crisis, Nation's Restaurant News, https://www.nrn.com/quick-service/starbucks-donates-10-million-grants-employees-need-during-coronavirus-crisis, [accessed on 16th May 2022]
12. Food and Agriculture Organization of the United Nations (FAO), (2020), Addressing the Impacts of COVID-19 in Food Crises April–December 2020: FAO's Component of the Global COVID-19 Humanitarian Response Plan, FAO, Rome, https://www.fao.org/documents/card/en/c/ca8497en, [accessed on 6th of January 2022].
13. Free, C. & Hecimovic, A. (2020), "Global supply chains after COVID-19: the end of the road for neoliberal globalization?", *Accounting, Auditing& Accountability Journal*, Vol.34 No.1, 2021 pp.58-84
14. Gereffi, G. (2020), "What does the COVID-19 pandemic teach us about global value chains? The case of medical supplies", *Journal of International Business Policy*, Vol. 3 No. 3, pp. 287-301.
15. Golan, M.S. et al, (2020), "Trends and applications of resilience analytics in supply chain modeling: systematic literature review in the

context of the COVID-19 pandemic", *Environment Systems and Decisions*, Vol. 40 No. 2, pp. 222-243

16. Handfield, R.B. et al (2020), "Coronavirus, tariffs, trade wars& supply chain evolutionary design", *International Journal of Operations & Production Management*, Vol.40 No.10, pp.1649-1660.
17. Hassen. T. B. et al, (2021), Food shopping, preparation and consumption practices in times of COVID-19: the case of Lebanon, Journal of Agribusiness in Developing and Emerging Economies, Vol. 12 No. 2, 2022 pp. 281-303
18. Ho. W et al, (2015), "Supply Chain Risk Management: A Literature Review", ResearchGate (online), https://www.researchgate.net/publication/272892367_Supply_Chain_Risk_Management_A_Literature_Review, [accessed on 2nd of April 2022].
19. Hobbs, J.E. (2020), "Food supply chains during the COVID-19 pandemic", *Canadian Journal of Agricultural Economics-Revue Canadienne D Agroeconomie* (online), https://onlinelibrary.wiley.com/doi/full/10.1111/cjag.12237, [accessed on 9th June 2021]
20. Huang. Y et al., (2021), "Predicting the Impacts of the COVID-19 Pandemic on Food Supply Chains and Their Sustainability: A Simulation Study", Discrete Dynamics in Nature and Society journal, Vol. 2021 No.7109432, pp.1-9
21. Ivanov, D. (2020), "Predicting the impacts of pandemic outbreaks on global supply chains: a simulation-based analysis on COVID-19 outbreak (COVID-19/SARS-CoV-2) case", *Transportation Research Part E: Logistics and Transportation Review*, Vol.136, p.101922

22. Ivanov, D. and Das, A. (2020), "COVID-19 (COVID-19 / SARS-CoV-2) and supply chain resilience: a research note", *International Journal of Integrated Supply Management*, vol. 13 No. 1, pp. 90-102
23. Ivanov, D. & Dolgui, A., (2020), "Does the ripple effect influence the bullwhip effect? An integrated analysis of structural and operational dynamics in the supply chain", *International Journal of Production Research*, Vol.58 No.5, pp.1285-1301.
24. Kamilaris, A. (2019), "The Rise of Blockchain Technology in Agriculture and Food Supply Chains", ResearchGate (online), https://www.researchgate.net/figure/A-simplified-food-supply-chain-system_fig1_335290647, [accessed on 14th May 2022]
25. Khan, S.A.R. and Ponce, P. (2021), "Investigating the effects of the outbreak of COVID-19 on perishable food supply chains: an empirical study using PLS-SEM", The International Journal of Logistics Management, Vol. ahead-of-print No. ahead-of-print, https://www.emerald.com/insight/content/doi/10.1108/IJLM-12-2020-0496/full/html, [accessed on 11th of July 2022]
26. Khatami. F, (2021), "Effects of globalization on food production in five European countries", *British Food Journal*, Vol. 124 No. 5, pp. 1569-1589
27. Kilpatrick, J. and Barter, L. (2020), "COVID-19: managing supply chain risk and disruption", Deloitte (online), https://www2.deloitte.com/content/dam/Deloitte/ca/Documents/finance/Supply-Chain_POV_EN_FINAL-AODA.pdf, [accessed on 14th February 2022]
28. Kumar, S. et al, (2021), "Journal of Retailing and Consumer Services What drives brand love and purchase intentions toward the local food distribution system? A study of social media-based REKO (fair consumption) groups", *Journal of Retailing & Consumer Services*, Vol. 60, 102444.

29. Lin, Q. et al (2020), "A conceptual model for the outbreak of Coronavirus disease 2019 (COVID-19) in Wuhan, China with individual reaction and governmental action", *International Journal of Infectious Diseases*, Vol.93, pp.211-216
30. Magzter, (2020), "Covid-19 Coronavirus Epidemic Has A Natural Origin", https://www.magzter.com/stories/Science/Scientific-India/Covid-19-Coronavirus-Epidemic-Has-A-Natural-Origin, [accessed on 5th March 2022]
31. Norris, C.L. et al, (2021), "Pivot! How the restaurant industry adapted during COVID-19 restrictions", International Hospitality Review, Vol. 35 No. 2, pp. 132-155.
32. Organization for Economic Co-operation and Development (OECD), (2020), "Food supply chains and COVID-19: impacts and policy lessons", https://www.oecd.org/coronavirus/policy-responses/food-supply-chains-and-covid-19-impacts-and-policy-lessons-71b57aea/#abstract-d1e27, [accessed on 11th of May 2022]
33. Raheem, D. et al, V. (2019), "Food system digitalization as a means to promote food and nutrition security in the Barents region", *Agriculture*, Vol. 9 No. 8, pp.168.
34. Ramos. E et al, (2021), Dynamic capabilities in the "new normal": a study of organizational flexibility, integration, and agility in the Peruvian coffee supply chain, Emerald insight (online), https://www.emerald.com/insight/content/doi/10.1108/SCM-12-2020-0620/full/html, [accessed on 11th of June 2022]
35. Rustici, C. (2020), "COVID-19: Europe must regain sovereignty over key industries", IDN-InDepth News (online), https://indepthnews.net/index.php/opinion/3507-covid-19-europe-must-regain-sovereignty-overkey-industries, [accessed on 24th May 2021].

36. Shadmi, E. et al, (2020), "Health equity & COVID-19: global perspectives", *International Journal for Equity in Health*, vol. 19 No. 1, pp. 1-16
37. Sharma, J. et al, (2021), "Exploration of COVID-19 impact on the dimensions of food safety & security: a perspective of societal issues with relief measures", *Journal of Agribusiness in Developing & Emerging Economies*, Vol.11 No.5, pp.452-471
38. Sheth, J. (2020), "Impact of covid-19 on consumer behavior: Will the old habits return or die?", Journal of Business Research, Vol. 117, pp. 280-283.
39. Shih, W.C. (2020), "Is it time to rethink globalized supply chains?", *MIT Sloan Management Review*, Vol.61 No.4, pp.1-3
40. Sinha, A. et al, (2020), Digital Supply Networks: Transform Your Supply Chain and Gain Competitive Advantage with Disruptive Technology & Reimagined Processes, McGraw Hill.
41. Thanh. P. T. et al, (2021), "Disruptions to agricultural activities, income loss, and food insecurity during the COVID-19 pandemic: evidence from farm households in a developing country", *Journal of Agribusiness in Developing and Emerging Economies*, Vol.12 No.3, pp.531-547
42. Udofia, E., et al (2020), Supply disruption in the wake of COVID-19 crisis and organizational performance: mediated by organizational productivity and customer satisfaction, Journal of Humanities & Applied Social Sciences, https://www.emerald.com/insight/content/doi/10.1108/JHASS-08-2020-0138/full/html, [accessed on 18th July 2021]
43. Van Hoek, R. (2020), "Research opportunities for a more resilient post-COVID-19 supply chain–closing the gap between research findings & industry practice", *International Journal of Operations & Production Management*, Vol.40 No.4, pp.341-355

44. Wang. Y et al, (2020), COVID-19, supply chain disruption and China's hog market: a dynamic analysis, China Agricultural Economic Review, Vol. 12 No. 3, pp. 427-443
45. Worku, A. & Ülkü, M.A., (2021), "Analyzing the effect of the COVID-19 pandemic on Veget market Supply in Northwestern Ethiopia", Journal of Agribusiness in Develop and Emerging Economies, Vol.11 No.4, pp.1053-1068
46. WTO (2020), "Trade set to plunge as COVID-19 pandemic upends global economy", https://www.wto.org/english/news_e/pres20_e/pr855_e.htm#:~:text=World&hx0025;20trade&hx0025;20is&hx0025;20expected&hx0025;20to,and&hx0025;20life&hx0025;20around&hx0025;20the&hx0025;20world, [accessed on 5th August 2021].
47. Yang. Y et al, (2020), "COVID-19 and restaurant demand: early effects of the pandemic and stay-at-home orders", *International Journal of Contemporary Hospitality Management*, Vol. 32 No. 12, pp 3809-3834
48. Zhu, G. et al, (2020), "Lessons learned from the COVID-19 pandemic exposing the shortcomings of current supply chain operations: a long-term prescriptive offering", *Sustainability*, Vol.12 No.14, pp.1-19.