IMRD
The International Master of Science in Rural Development

FACULTY OF BIOSCIENCE ENGINEERING
vliruos
SHARING MINDS, CHANGING LIVES

Co-funded by the Erasmus+ Programme of the European Union

Academic year 2020 - 2021

THE FRAGILITY OF KENYA'S CUT FLOWER SECTOR AND IMPACTS AS EXPOSED BY COVID-19

KOECH ELIZABETH CHEBET

Promotor: Prof. Marijke D'Haese

Co-promoter: Dr. Daniel Joordan

Tutor: Wannes Slosse

Thesis submitted in partial fulfilment of the requirements for the joint academic degree of International Master of Science in Rural Development from Ghent University (Belgium), Agrocampus Ouest (France), Humboldt University of Berlin (Germany), Slovak University of Agriculture in Nitra (Slovakia), University of Pisa (Italy) and University of Córdoba (Spain) in collaboration with Can Tho University (Vietnam), China Agricultural University (China), Escuela Superior Politécnica del Litoral (Ecuador), Nanjing Agricultural University (China), University of

Agricultural Science Bengaluru (India), University of Pretoria (South-Africa) and University of Arkansas (United States of America)

This thesis was elaborated and defended at ……GHENTUNIVERSITY……. within the framework of the European Erasmus Mundus Joint master's degree "International Master of Science in Rural Development " (Course N° 2015 - 1700 / 001 - 001)

Certification

This is an unpublished M.Sc. thesis and is not prepared for further distribution. The author and the promoter give the permission to use this thesis for consultation and to copy parts of it for personal use. Every other use is subject to the copyright laws, more specifically the source must be extensively specified when using results from this thesis.

The Promoter(s) (name(s) and signature(s))

The Author (name and signature)

Thesis online access release

I hereby authorize the IMRD secretariat to make this thesis available online on the IMRD website

The Author

(name and signature)

ACKNOWLEDGEMENTS

A special acknowledgement to Professor Marijke D'Haese, for steering me into this important field of the cut flower value chain and her guidance towards the critical issues in the sector.

Special thanks to Dr. Daniel Joordan, Department of Agricultural Economics at Pretoria University for Introducing me to new value chain analysis concepts and guiding me throughout the research process . Your tireless efforts are truly appreciated.

Grateful salutations to Wannes Slosse for being a short message away, always ready for a good brainstorming. Your support was felt throughout this process. Thank you.

Finally, to Mr. Timon Bowen of the Horticultural Authority of Kenya without whom I would not have a foot in the industry. Your contacts opened doors that facilitated my research and for that I am grateful.

Abstract

The Covid -19 pandemic has been termed as an atypical event that has disrupted global value chains bringing back into focus key debates on supply chain resilience. The cut flower chain in Kenya was most impacted by the pandemic in various ways such as; (1) Lockdown policies that included curfews, restricted movements of farm personnel, and the flower commodity between regions and closure of boarders, (2) Workers sent home, (3)Bullwhip effects on supply of inputs, (4) Logistical breakdowns as a result of grounding of flights, curtailed movement of trucks, (5) Loss of revenue, (6)Closure of markets due to cancellation of weddings, and non-essential retail stores such as florists (Kenya flower council, 2020). To further understand these impacts, this study assessed the fragility of the sector using the heuristic stress testing mechanism. Fragility is defined as the property of a shocking event on a chain to have an accelerated and exaggerated non-linear impact on the system (Taleb et al., 2012). Twelve critical factors identified in literature (Jordaan, 2017; Stonebraker et al., 2009) were analysed. They include, supplier and buyer relationships, quality and safety performance, operational reliability, chain complexity, information and communication, infrastructure among others. The factors were measured based on their deviation from linearity. The resulting outputs of the study include fragility scores per factor, a map showcasing key fragility factors in the sector and comparisons of mean fragilities between different levels of value chain coordination. The study found significant differences in chain actors' fragility among different levels of chain dependency, thus proving a trade-off exists between

chain performance and safety. Finally, the paper provides insights on the impacts of the pandemic lockdown policies on different chain players in the cut flower sector.

Table of Contents

List of figures

List of tables

1 Introduction

At the onset of the COVID-19 pandemic, governments around the world implemented lockdown policies that caused significant restrictions on the majority of day-to-day operations, key among them movement of goods as well as labour. This came at great economic costs (Maples et al., 2021; Ruan et al., 2021). A survey conducted by the Chartered Institute of Procurement and Supply found that between eighty to ninety five percent (80-95%) of supply chains were impacted by COVID-19 lockdowns (Hart, 2020) thus calling for the internal introspection of sectors globally to reinforce resilience.

While COVID-19 lockdown policies exposed textbook demand and supply risk scenarios, the rarity and extremity of this pandemic made it impossible to predict. Even before the pandemic hit, there had been requests for more empirical and event-based research on supply chain resilience (Remko, 2020) because of recurrences of food safety scandals (Ma and Liu, 2019), trade wars (Shangquan, 2000), climate change induced extreme weather events (Jira & Toffel, 2013) among other risky events.

One of the key sectors affected by the pandemic in Kenya was the cut flower sector. The sector was extremely impacted by the lockdown restrictions because of the global spread of the value chain where producers are mainly situated in the Global South, namely in Africa and South America, while wholesale auctions and markets are based in the Global North, in Europe and the US (Hughes, 2000). Therefore, the closure of borders greatly interrupted logistical flows of the flowers . Flowers are highly perishable products, hence involve an extremely fragile and risk prone value chain. As Hughes,

(2000) explains, every day a flower is delayed in shipment it loses its value by fifteen percent (15%), therefore prompt transport and logistics is key for efficiency in this chain.

In an industry press briefing with the international media, the CEO of Kenya flower council confirmed that the grounding of flights during the lockdown had the biggest impact on operations, causing a logistical breakdown which brought the sector to its knees. He explained that typically there were about twenty direct flights from Kenya to the Netherlands but this was grounded to zero in March 2020 (Reuters, 2020). The cancellation of flights suspended the country's main means of transportation of cut flower export. Cargo planes remained operational but were curtailed with restrictions. Mr. Tulezi also reported that demand and cost of shipment spiked from $1.85 per kg before the pandemic to approximately $4 per kg on average during the lockdown. He explained that priority was given to shipment of foods and food products such as snow peas, carrots, lettuce, sugar snaps, baby corn and herbs as food was deemed the most important supply chains at the time. By April 2020 exports had slumped to only twenty percent (20%) of the produced output (Kenya flower council, 2020).

The impact was also felt in consumer markets, the flower council of Europe, Union Fleurs reported a loss of 1.2 billion euros within the first six weeks of the lockdown across 17 EU countries (Union Fleurs et al., 2020). This significant loss was as a result of disruption of supply of the flower commodity from the global south due to movement restrictions and the loss of markets resulting from cancellation of events (weddings, parties), restricted meeting of family and friends, and closure of non-essential shops such as florists and open air markets (Union Fleurs, 2020).

The pandemic has elicited a lot of research on resilience of value chains to extreme events, mostly focusing on risk analyses. However, as explained later on in this dissertation, focusing on risk analysis is missing the mark, as an atypical event like the COVID-19 pandemic is impossible to predict recurrence. Taleb et al., (2012) explains, it is impossible to predict probability and distribution of risks in atypical events. Rather Jordaan, (2017) suggests that an assessment and identification of weak links and vulnerabilities in value chains in the form of a fragility analysis is the best contingency measure to assess and prepare for emerging atypical events.

Therefore, this study conducted a fragility analysis of Kenya's cut flower sector as exposed by the recent pandemic and highlighted the impacts of lockdown restrictions on the chain actors. This study sought to create a clear understanding of the structure of the cut flower sector and establish the network of operations among various chain actors through examination of the whole chain. It used the formula for value chain analysis developed by Gereffi, (1996). The study was also interested in measuring chain fragility through assessing the performance of twelve chain fragility factors identified in literature (Jordaan, 2017; Stonebraker et al., 2009) including; supplier and buyer relationships, operational reliabilities, chain complexity, information and communication, quality and product performance, infrastructure, state of the economy and socioeconomic stability among others. The fragility scores of these factors were then compounded into a composite index to determine which actor is most fragile (Jordaan and Kirsten, 2019). Finally, an assessment of the impacts of the lockdown on the performance of the sector was conducted.

In summary, the analysis allows for a chain view of the vulnerabilities in the sector and showcased the consequences of an atypical event in the chain. A more granular picture of the exposure to and consequence of adverse events will enable strategy development towards greater resilience of the underlying businesses, the value chain, and the sector as a whole. The results of the study can be generalized to other global value chains with dependency on agricultural producers in the Global South.

1.1 Research question

How was the Kenyan cut flower sector affected by the COVID-19 pandemic and which factors of fragility were most pronounced?

1.2 Objectives of the study

1. To describe the impact of the lockdown policy on the performance of the cut flower sector.
2. To determine the factors that contribute to fragility per factor per function in the production and export of cut flower in Kenya as exposed by the COVID-19 restrictions.
3. To determine the fragility of the cut flower chain and showcase the consequences to an atypical event on its performance.

The rest of this paper is structured as follows; after highlighting the background and pertinent issues of this study, this dissertation examination of literature on studies tackling the effect of the pandemic on agricultural supply chains. Thereafter I describe the chain of interest - the cut flower sector in Kenya in detail, I then introduce the concept of fragility and apply a fragility analysis on the sector. Finally, I assess the impact of the lockdown policy on various actors.

2 Problem setting

There is a lot to unpack in terms of the domino effects of the pandemic. Among other aspects, the pandemic has brought back key international trade debates on trade relations (Kerr, 2020), sustainability of lean chains (Ivanov, 2020), de-globalization (Zhang, 2021), and near shoring vs. far shoring (Hoek, 2020).

The measurement of the impact of the pandemic is a complex matter due to the multifaceted nature of the economy and the underlying cause-effect relationships between multiple variables within its sectors. However, scientists around the globe have commenced the attempt to measure the impacts of the lockdown policy on key agricultural value chains. Ruan et al., (2021) used the time regression discontinuity method to monitor the identify and quantify the causal effects of the strict lockdown policy on vegetable prices using multiple-year daily price data from one hundred and fifty wholesale markets of Chinese cabbage. They found that lockdown policies caused a sudden surge in price and price dispersion of Chinese cabbage and that the pattern fluctuated less smoothly than the same period in previous years. The authors further showed that the price surge peaked in the 4th week of the lockdown but gradually came down to the level of a normal year by week 11 of the lockdown. Aday and Aday, (2020) reviewed the impact of the pandemic on food supply chains. They highlighted concerns on how food production, processing, distribution, and demand were impacted by the pandemic. They went further to mention key impacts such as restrictions of movement of workers, changes in demand of consumers, closure of food production facilities, restricted food trade policies, and financial pressures in food supply chain. Aday and

Aday, (2020) suggested that governments facilitate the movement of workers and agri-food products, advocated for the financial support of farmers or vulnerable people, and avoid food protectionist policies. Finally, they recommended that governments should constantly assess situations and tighten or loosen measures according to the spread of virus to fast-track recovery of agricultural supply chains. Another study by Kerr, (2020) focused on the impact of the pandemic on trade relations in agricultural supply chains. He contended that since the pandemic, governments may wish to strengthen institutions that govern international trade. On the other hand, he explained that countries may realise their dependencies on foreign sources of supply and may wish to reverse the impacts of globalization on their food systems. As a result, they may become increasingly isolationist, which would be detrimental to international cooperation.

In East and central Africa, Nchanji and Lutomia, (2021) used data from bean farmers in the region to descriptively study the regional impact of COVID-19 on food security. They found that the pandemic created significant bean production challenges, including low access to seed, farm inputs, hired labour, and agricultural finance. They expressed concern that the pandemic would reverse gains made in the achievement of sustainable development goal one and two, saying countries in Southern and Eastern Africa were more likely to suffer temporary food shortages as a result of the pandemic than their western counterparts. The study lauded governments for providing economic stimulus packages but recommended that more needed to be done to increase the resilience of food systems in the region.

Another interesting approach by Morton, (2020) suggested the replication of a conceptual framework that was once used to assess the impact of the HIV epidemic on agricultural livelihoods on developing countries. He explained that the framework would assess the susceptibility, resistance, vulnerability to impacts and resilience building in the wake of the pandemic, further stating that the framework allows the clear formulation of key questions for COVID-19 such as factors in the labour process that make people more or less susceptible, broader socioeconomic and biophysical determinants of susceptibility, factors that make farm households, food enterprises and value chains more vulnerable to the impacts of the pandemic, and aspects of COVID-19 responses by governments and the private sector that might increase vulnerability. Although it was an interesting framework, actual studies have yet to be done using data from the COVID-19 pandemic.

Most research has categorised the lockdown policy as a risk to business and therefore used classical concepts of risk management to analyse COVID-19 impacts. Hobbs, (2020) investigated the demand-side factors including panic buying by consumers and changing consumer preferences and supply-side factors such as disruption in movement of goods in the supply chain, labour shortages and logistics that were observed during the lockdown period. She criticized the just- in- time supply chain model that has become increasingly popular, stating that the experience in the early stages of the pandemic suggest that this model is vulnerable to short-run disruptions caused by external demand and supply shocks. In concluding , she argued that the pandemic would have

long lasting effects on the nature of food supply chains with increasing growth of online grocery shopping and more prioritization of local food chains.

Finally, Sharma et al., (2020) assessed agricultural supply chain risks caused by the pandemic using the Fuzzy Linguistic Quantifier Order Weighted Aggregation (FLQOWA).Their findings showed that demand and supply risks, financial risks, logistics and infrastructure risks, management and operational, policy and regulation, and biological and environmental risks had an impact on agricultural supply chains. They suggested strategies to mitigate these risks including adoption of industry 4.0 technologies, supply chain collaboration and shared responsibility among chain actors.

Though comprehensive, these studies failed to take into account the unpredictability of recurrence of the pandemic. Risks analyses use the probability of recurrence to determine if a factor is risky or not. However, the COVID pandemic has been described as an atypical “black swan” event because of its rarity and unpredictable recurrence. therefore, conducting a risk analysis only explores the dimensions of current situation hoping it recures in the same way in future. As Jordaan & Kirsten, (2019) contend, this does nothing for future preparedness. To counter this shortcoming, they propose an analysis of the weak links and areas most vulnerable to risk as the best measure for future preparedness.

Fragility analysis was first conducted by Taleb et al., (2012) in the banking sector in the US. They used a heuristic test to study the impact of macroeconomic stress on key financial risk drivers, namely credit losses, credit growth and pre-impairment income.

Taleb et al., (2012) proposed the use of a heuristic test as a technique that provides a way to assess how non-linear tail risks appear and hence assess sensitivity of outcomes of stress tests on various risk drivers. The test was applied to bank capitalization, for the specific risk drivers such as credit growth, credit losses, trading income. The outcomes of their study showed tail stress test produces non-linear results in the majority of cases hence indicating fragility in the sector.

Jordaan, (2017) tested and adopted this method to agricultural supply chains. Through Delphi rounds and factor analysis, he developed seventeen fragility factors to be assessed in agricultural supply chains and used the heuristic tests to measure fragility. This method was then applied to the South African Lamb value chain. Here producers, abattoirs, packers, distributors, and retailers of lamb were investigated. The findings of the analysis was a commonality in certain factors consistently scoring highly in fragility scores from the production level through to retailing. Secondly, they concluded that despite commonalities, a range of fragilities were specially localized to a specific chain player or activity, which highlighted the challenges and uniqueness of individual specific activities in the chain.

3 The cut flower sector in Kenya

Kenya is classified as a middle-income industrialized economy (World Bank, 2021). Like most developing countries, it depends on primary agricultural production for its gross domestic product, thanks to its natural endowments of suitable agricultural land and cheap labour (Rapsomanikis, 2015) among others. The country relies heavily on importation of input supplies such as fertilizers, chemicals and machinery for production and also relies on export markets of its raw commodities for further processing in third countries (WITS, 2019) meaning the country sits right in the middle of the global supply chain. The very nature of the spread of its operations exacerbates risks classically experienced by developing countries in relation to globalization (Shangquan, 2000). Among the leading income earners for the country is cut flower production. This sector is valued at approximately one billion dollars and contributes to two percent (2%) of the gross domestic product (GDP) of the country (Statista, 2021). Kenya is the fourth largest exporter of cut flower worldwide coming after the Netherlands which contributes (45.6%), Colombia (17%), Ecuador (10%) and Kenya (7%) of world exports of flowers (OEC, 2021) (Figure 1).

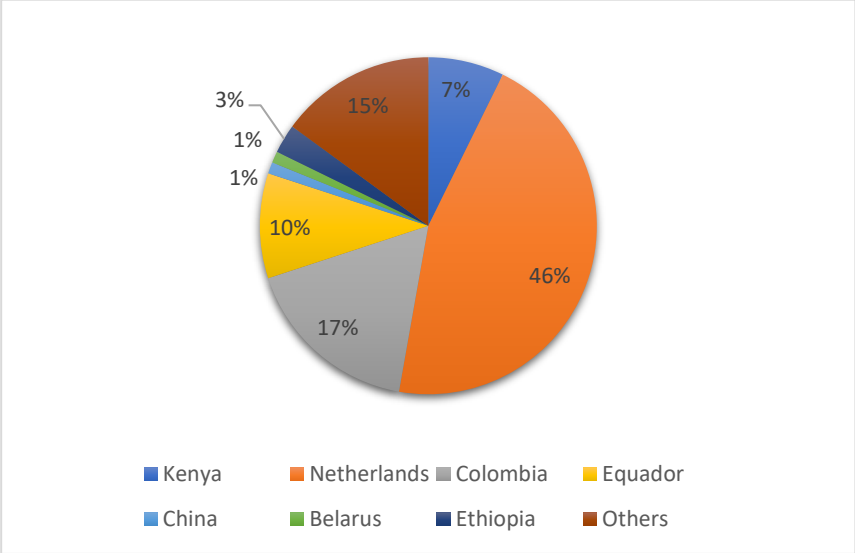


Figure 1: Global cut flower exports. Source: (OEC, 2021)

The sector is growing fast and has outpaced traditional income sources such as tea and coffee. Kenya enjoys a natural competitive advantage in cut flower production over its counterparts. It is endowed with the key physical and climatic environment needed for floral production. The country lies strategically on the equator where the sun shines twelve hours a day, an ideal condition for sun loving flowers (Bolo, 2008). It is also endowed with cheap labour and access to lake water for irrigation. In their paper analysing Kenya's competitiveness in the flower Industry, Adeola et al., (2018) state that Kenya has a wealth of trade facilitation experience in exporting cash crops like tea and coffee for nearly a century which has proved valuable in cut flower export. This comprises of a robust business enabling environment, simplified and harmonized processes of international trade, functional institutional frameworks, and favourable business legislation. Together they have aided the nation achieve the profile of an international year-round supplier of cut flower.

4 Value Chain Analysis of the cut flower sector

Riisgaard & Gibbon, (2014) describe the cut flower chain as a buyer-driven chain characterised by high information costs, tightly linked relationships between actors and advanced supply chain management systems that set up entry barriers. To further understand the structure and flow of operations of this sector, this study used the method of value chain analysis proposed by Gereffi, (1996) that consists of analysing the (1) input-output structure, (2) territory covered, (3) governance structure and (4) institutional frameworks.

4.1 Input output structure

The main input suppliers provide seedlings, cuttings and grafts for production, soil fertility and plant nourishment materials and greenhouse and irrigation system installations. In most cases producers are dependent on a few suppliers for all inputs and the relationship allows for sourcing on credit (Adeola et al., 2018). The growers are in charge of primary production. They plant, tend to, harvest and conduct post-harvest handling to the flowers. The technologies used include fertigation systems, pruning, glass houses, pre-cooling, cold storage, grading, bouqueting, fertilizer recycling, wastewater treatment, grading and packaging sheds, and refrigerated trucks in their production and processing (Xia et al., 2006).

The Horticultural Development Authority estimates that currently over two hundred (200) registered flower farms are involved in the production of cut flowers in Kenya. The production is concentrated in medium and large-scale flower operations ranging from

20-100 hectares (HCA, 2021a). Lake Naivasha is the biggest cut-flower producing region in Kenya, with approximately seventy (70) farms covering over three thousand (3,000) hectares with greenhouses, employing an estimated fifty thousand (50,000) people, and producing roughly eight thousand (8,000) metric tonnes of flowers, mainly roses, per month (HCA, 2021b). Other areas of production are Mount Kenya, Kajiado and Uasin Gishu. The main cut flowers grown in Kenya are carnations, roses and Alstroemeria. Summer flowers cultivated include, hypericum arabicum, gypsophilla, Lilies Eryngiums, and Statice (HCA, 2021b; Mekonnen et al., 2012). There are emerging middlemen in the form of agents and informal merchants in the sector who buy and consolidate flowers from producers for export. These actors have direct relationships with markets overseas and are known as consolidators (Rapsomanikis, 2015).

The biggest channel through which Kenya's flowers are sold is the Dutch flower auctions (Xia et al., 2006). The Royal Flora Holland flower auctions and the Bloemenveiling Aalsmeer, Netherlands, are the key institutions at the epicentre of operations in the cut flower sector. They are the platform for price setting and the avenue through which producers meet consumer demand (Xia et al., 2006). The auctions receive cut flowers from over fifty (50) countries including Kenya, Ecuador and Colombia and re-exports them handling about sixty (60%) of the world's cut flowers (Govoni, 2012) . Major supermarket chains in the UK are venturing into direct sourcing contracts with local farmers (Hale & Opondo, 2005). Additionally, there are emerging markets from the Gulf states. This is attributed to the economic emergence of the gulf states to high income economies allowing for the demand of this luxurious commodity (Assad, 2007).

The main retailers and end markets of flowers are supermarkets, florists' shops, home depots, convenience stores and discount warehouse chains (Hughes, 2000).

Figure 2 is a basic value chain map of the cut flower chain.

The Cut flower value chain

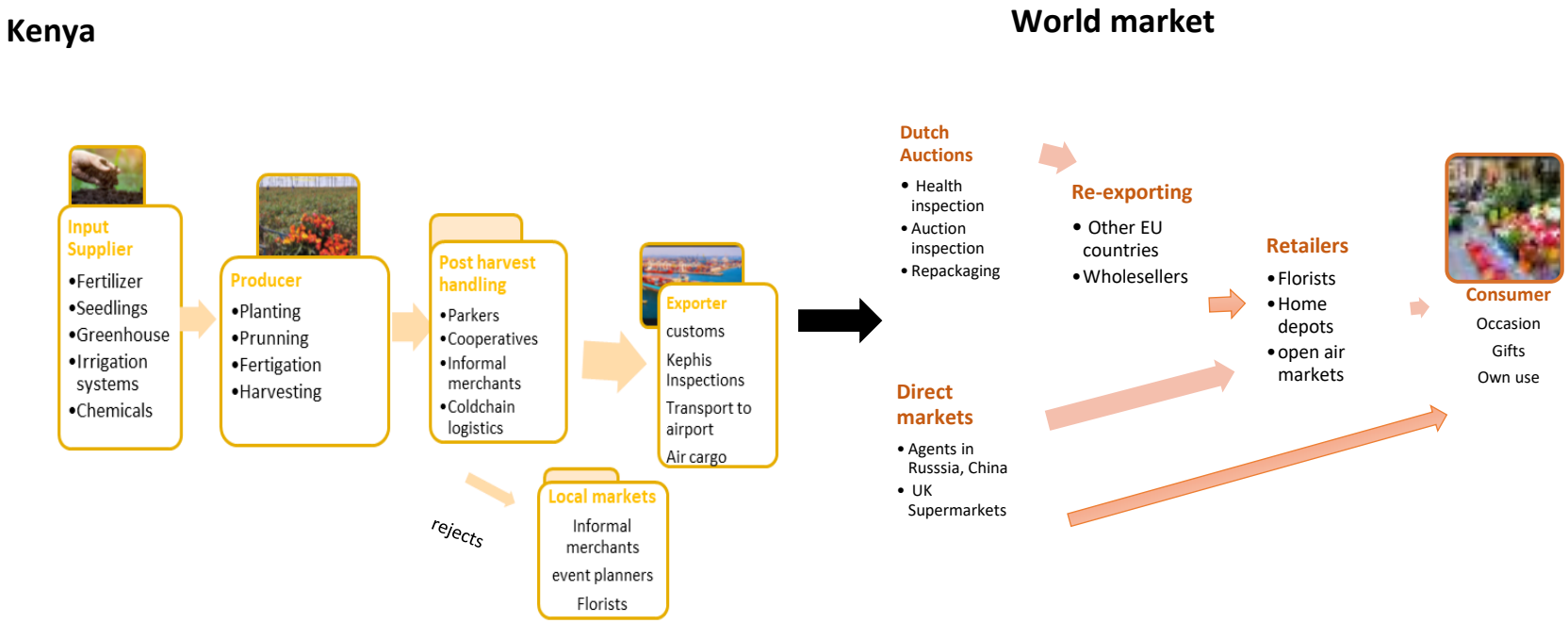


Figure 2: Authors illustration of the cut flower chain

4.2 Territory covered

The cut flower value chain is spread globally. Today, the producers are mainly situated in the Global South, namely in Africa and South America. This is attributed to the suitable climatic conditions. Kenya, Ecuador and Colombia lay on the equator, hence enjoy abundance of sunshine throughout (Hughes, 2000). The abundance in cheap labour, available land and low production costs also favour production in these regions. Wholesale auctions and end markets are based in the Global North, in Europe, Asia and the US (Hughes, 2000), who have the culture and economic capacity to consume this luxury commodity.

4.3 Value Chain Governance

According to classification of governance mechanisms introduced by Gereffi et al., (2005), the cut flower chain governance can be described as a relational value chain because of the networks with complex interactions between buyers and sellers and the high levels of asset specificity. As a such, the chain consists of a flow of goods (inputs and flowers), finance and information in a relationships-based governance structure managed through decades of mutual interdependence.

One of the determinants of vertical co-ordination is the nature and level of transaction costs arising from the exchange of a product. As the degree of asset specificity and uncertainty in the market increase, there is a greater demand for vertical integration (Gereffi et al., 2005). Value chain governance studies show an increased adoption of vertical integration as a popular governance mechanism in value chains. Most organizations are in favour for vertical integration because of its potential to reduce

transaction costs (Mahoney, 1992) reduce risks (Den Ouden et al., 1996) and improve market position (Perry, 1989).

4.3.1 Vertical integration

The cut flower sector is highly vertically integrated characterised by mutual interest, information sharing, interdependence, and long-term relationships (Chege, 2012). Actors take up more than one role in the chain with most having cross-continental operations spreading from flower production, export and wholesale (Hughes, 2000). This has yielded a highly vertically integrated chain, which is also vulnerable to unpredictable to changes in all aspects hence actors in the chain face uncertainty.

While this governance mechanism is picking up popularity across different sectors, most chains are overlooking the obvious risks that come with vertical integration including that it exposes the sector to fragility. Wever et al., (2012a) explains that supply chain actors follow recommendations from the traditional transaction cost economics models regarding the use of closed relationships between actors, which he contends limits alternative channels of distribution and may increase rather than decrease their exposure to transaction risks. These sentiments are reiterated by Zeng & Yen, (2017) who explain that although vertical integration aims for chain optimization, the increased globalisation of operations characterised by specialised production units, limited suppliers, and specific distribution channels and markets expose chains to new risks.

To add to this, Wever et al., (2012b) contends that the type and the channel through which chain players are directly or indirectly linked, model how these players would

be influenced by externalities. Similarly, Mentzer et al., (2001) argues that the degree of dependencies affect levels of systemic risks as they contribute to susceptibility to mishaps in the movement of commodities and finances. Thus, interdependencies expose agri-food chains to uncertainties and risks that may arise either internally or externally and cause disruptions (Jordaan, 2017).

4.3.2 Types of dependencies

Vertical integration leads to different types of interdependencies among actors. Kembro and Selviaridis, (2015) worked on the differentiation of levels of interdependencies. Pooled interdependency is described as a level of dependency where players work together as separate individuals with loose links and only share some common interests. It is considered a weak form of interdependency with low a degree independence. An example would be producers of cut flowers depending on a single input provider (figure 3).

Sequential interdependency consists of direct linkages between chain players. Here, the inputs of one chain player are directly dependent on the output of another chain player hence they consists of preceding activities in a chain (Kembro and Selviaridis, 2015). An example would be consolidators depending on the output of producers and international agents depending on the output of the consolidator.

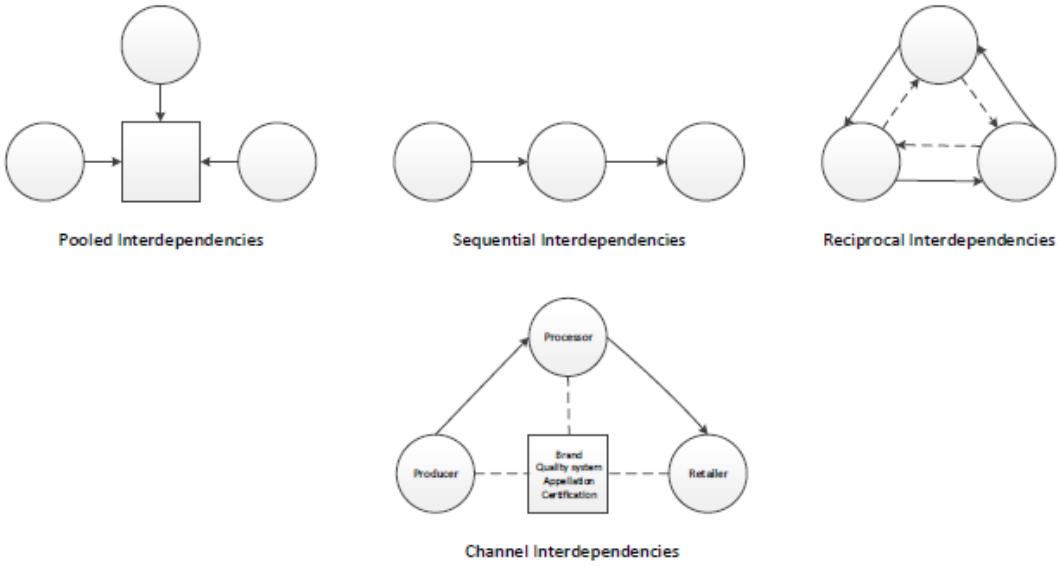


Figure 3: Types of dependencies of actors in a value chain. Source: (Kembro and Selviaridis, 2015)

Reciprocal interdependency occurs when the inputs of one chain player are directly dependent on the outputs of another chain player and *vice versa.* Therefore, there is a mutual exchange of inputs and outputs between chain players (Kembro and Selviaridis, 2015). Channel interdependencies involve a common link of their engagement in the systems such as quality management schemes (Wever et al., 2012b). An example would be the dependence on KEPHIS for phytosanitary certification and EUREPGAP inspections. These classifications; pooled, sequential, channel and reciprocal were used in our research questionnaire to determine levels of interdependencies of a particular respondent, where the former two indicated lower levels of interdependencies while the latter indicated higher levels of interdependencies.

4.4 Institutional frameworks

The cut flower sector is supported by key institutions in the Kenyan government and by private organizations. The Horticultural Crops Directorate is a government body that develops and coordinates the production and marketing of horticultural produce in Kenya. Their role include regulating, promoting, developing and facilitating operations of the cut flower sub-sector to ensure a smooth production and marketing environment and to advocate for policies that favour investment and enhanced performance of the sub-sector (HCA, 2021b).

The Kenyan Phytosanitary Inspection Service (KEPHIS) is a government parastatal with the responsibility to provide a science-based regulatory service by assuring plant health, quality of agricultural inputs and produce. They provide plant variety protection, conduct phytosanitary inspections including pest residue level tests in the farm and on cargo trucks to ensure quality of produce before export (KEPHIS, 2021).

In the private sector, the Kenya Flower Council is a business membership organization that advocates for interests of flower producers and exporters. It is the main institutional body representing eighty percent (80%) of the flower industry in Kenya. Among its main roles are advocacy and partnerships, ensuring compliance to standards, data management, trade facilitation, Innovation for sustainability, communication and capacity building (KFC, 2021).

The Fresh Produce Exporters Association of Kenya (FPEAK) is Kenya's premier trade association representing growers, exporters and services involved in growing and/or exporting fresh cut flowers, fruits, and vegetables. FPEAK provides a focal and

coordination point for the horticulture export industry. They support growers and exporters by providing technical and marketing information and training on among other issues compliance standards, act as an information centre, and run active lobbying and advocacy programmes to enhance the sector's competitiveness (FPEAK, 2021).

Global GAP is a quality assurance scheme that sets phytosanitary standards of farm produce including pest residue testing, produce safety environmental sustainability. They perform trainings, inspections, and certification of flower farms. They are the umbrella body from which EUREPGAP (European requirements and Kenya GAP (Kenyan requirements) are enclosed. The standards are mandatory for producers exporting to overseas market (GLOBAL GAP, 2019).

Fairtrade Kenya is an independent non- profit that represents the interest of producers and strengthens producer organizations by advocating for fair prices, proper work conditions, and sustainable production through policy advocacy and capacity building. They provide Fairtrade certification to members in compliance (Fairtrade, 2021). These institutions work together with the Ministry of Agriculture, Livestock, Fisheries and Cooperatives, Ministry of Industry and Trade, Kenya National Chamber of Commerce and Industry and the Horticulture Research Institute to deliver a reliable value chain.

The institutional framework in the cut flower chain greatly influence the governance of the sector. As seen above, each institution's roles are indispensable, being that they are regulatory and oversight bodies. Each institution leads to a certain type of

transaction cost. Government bodies like the horticultural development authority mostly apply policing and enforcement costs, while in the private institutions such as the Kenya flower council cover search and information costs on behalf of producers and exporters. Fairtrade for example cover bargaining costs. Though necessary, institutional frameworks increase transaction costs. Ultimately, these transaction costs are paid directly by chain actors either in form of taxes and levies or membership and compliance fees.

5 Value chain fragility

5.1 The concept of fragility

The concept of fragility is not new. However, it is often entangled with risk analysis despite its vast differences. Taleb et al., (2012) explains that while risk analysis seeks to predict the magnitude and probability of an undesirable event occurring, it is impossible to predict atypical events' magnitude and probability of recurrence. Fragility is observed when an "event" has accelerating impact on the system.

Agriculture supply chains are prone to great uncertainty such as food safety scandals (Ma & Liu, 2019), trade wars (Gaonkar & Viswanadham, 2007) and climate change induced extreme weather events (Linkov et al., 2014). These prove to be a threat to business continuity. Pettit et al., (2010) define chain vulnerability as "exposure to a harmful or serious disturbance or stressor, arising from risks within and external to the chain." The result of chain vulnerability is chain fragility. Taleb et al., (2012) defined chain fragility as "…the property that stressors bring disproportionately higher harm

than the stress…". They emphasizes on the non-linear feedback resulting from an atypical event as the true indicator of fragility.

Figure 4 illustrates how the consequence of a risky event increases with the severity of the event. If a chain is resilient, it will have linear resulting impacts. If it is fragile, the resulting Impact will be accelerated losses that cause concavity and if anti-fragile, it can take advantage of the risky event and make a profit (Jordaan & Kirsten, 2019) .

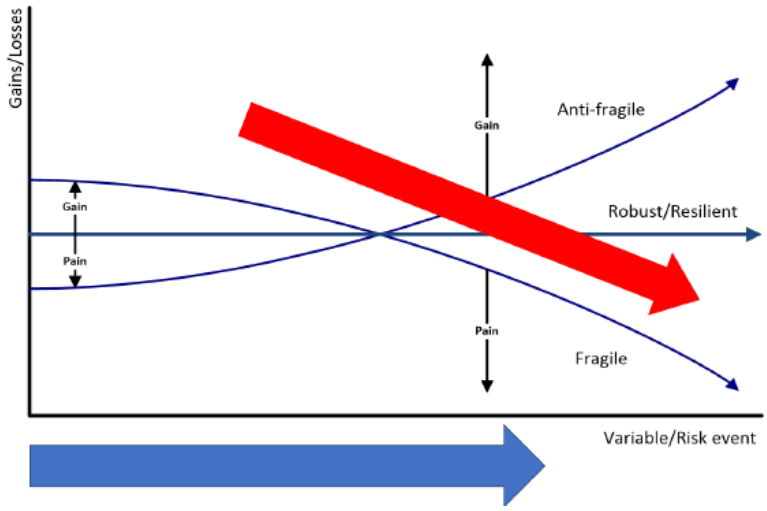


Figure 4: Fragility concept (Jordaan & Kirsten, 2019)

5.2 Chain fragility factors

There exist key factors that are critical when assessing the fragility of a value chain. Each chain has specific aspects that affect operations and continuity of business. In literature, two studies highlight this. This dissertation draws factors to be analysed from the studies by Stonebraker et al., (2009) and Jordaan, (2017). Thereafter it measures how each factor impacts business continuity with a unit level of increase in

deterioration of the factor. Stonebraker et al., (2009) identified the following chain fragility factors mentioned in Table 1.

Table 1: Fragility factors by Stonebraker et al. (2009)

Internal factors	
Physical logistics	Mechanical breakdowns; Damage en route, Shipping
Behaviour of key suppliers	Key supplier going out of business, Significant increase in prices; Contract limitations
Behaviour of customers	Changes in market share (change in customer preferences)
Information, communication, and control systems	Data accuracy and integrity, Feedback, and feed forward, Quality control, Inventory control, Scheduling, delivery, and control
Product and process design safety	Maintainability; Appeal; Efficiency; Costs; Non-replicability
People	Labour; Training; Professionalism
External factors	
Legal, political, and acts of government import duties	Trade barriers, Lack of political stability, Form of government (dictatorship, Etc.);
Behaviour of competitors, price wars	Competitors acquiring a key supplier
Financial, accounting, and economics foreign exchange risk;	Interest rate risk; State of the Economy
Environmental impact	Pollution, Recycling, Eco-health, Reverse supply chain unanticipated/random events
Other factors	
Unanticipated/random events	
Acts of nature	(Weather) Earthquake; Flood, Storm, Fire, etc.
Other external factors	War, terrorism, and piracy; Distance and time;
Language and culture	Barriers

Another study by Jordaan, (2017) has similar components however it categorizes the elements into three groups, namely: chain factors, external factors and Internal factors as given in Table 2.

Table 2: Value chain fragility factors based on Jordaan & Kirsten (2019)

CHAIN FACTORS	**EXTERNAL FACTORS**	**INTERNAL FACTORS**
Supplier relationship	State of the economy	Operational reliability
Buyer relationship	Social stability, reputation	Quality, safety performance
Information sharing	Laws, regulations, rules	Supplier reliability
Communication	Supporting infrastructure	Human resources
Chain links and dependency	State of the economy	Cash flow
Quality of data	Social stability, reputation	Information visibility

A classical business environment is affected by Internal and external factors (Worthington and Britton, 2009). Hence chain fragility factors are derived here. When measuring the relationship with buyers, this study examined the business culture, ethics, size, goals, duration of relationship, quality of relationship. Fir the degree of chain complexity the study analysed number of links, number of suppliers, number of buyers, number of products. The factor, state of the economy and prices entailed interest rates, economic growth rate, consumer spending, consumer debt, market prices whereas the quality and adequacy of supporting infrastructure such as roads, electricity, water, communication, exchanges affect functioning of business. These factors are influential in a business performance hence were used in analysing points of fragility in the cut flower chain.

6 Methodology

6.1 Fragility measurement

6.1.1 The fragility model

Taleb et al., (2012) proposed the use of a heuristic test as a robust measure of relative fragilities. They describe this as a test involves finding the difference between average shocks and average over a range of shocks. Plotting an event size against its impacts (level of harm) may result in a linear curve, demonstrating the impact of an adverse shock as proportional to the size of the shock, hence predictable. However, if the resulting plot of the event size against its impact is concave (negatively convex) in the tails, then the shock is disproportionately larger than the event size. This concave form is synonymous with atypical events, where a harm causes accelerated impacts. Therefore, when an event affects the value chain and causes accelerated negative impact with non-linear multiplicative effects, it indicates the fragility of the system (figure 5).

In summary, the measurement of fragility using Jensen's inequality test and can be expressed as follows, namely:

Fragility = Average shock – Average over a range of shocks (Taleb et al., 2012)

Equation 1 : $F=\frac{f(\alpha+\Delta)+f(\alpha+\Delta)}{2}$ -f(α))

Where F is the fragility score, f(α) is the gain or loss for a certain level α in the state variable concerned; Δ is a change in α, a certain multiple of the mean deviation of the

variable (Taleb et al., 2012).They concludes that if a factor has a negative value of F, it is considered more volatile and fragile (figure 4).

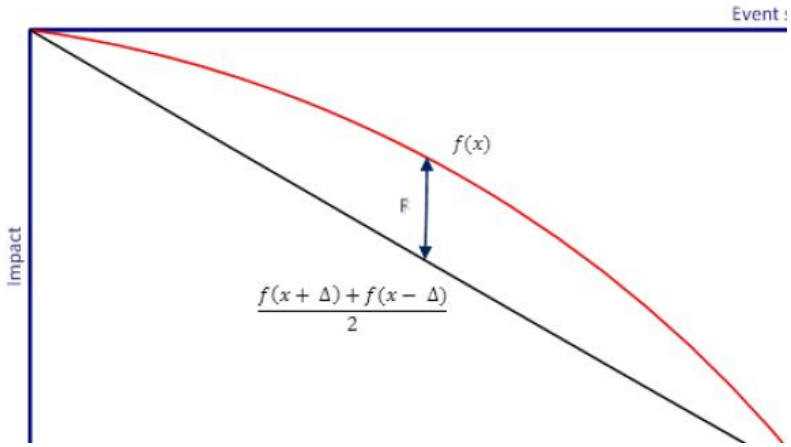


Figure 5: Detection of fragility (Taleb et al., 2012)

In our case the COVID-19 pandemic is the risky event which although being a public health issue, has affected all sectors significantly, including agriculture. It is an atypical event that generated an accelerated impact. The impacts of the pandemic have been disproportionately larger than the pandemic itself, hitting all aspects of life. The accelerating effects of the pandemic on the cut flower sector identified in literature include: (1) Lockdown policies; curfews, restricted movements between regions and closure of boarders) (2) Laying off of workers (3) Bullwhip effects on supply of inputs, leading to hiking of prices (4) Logistical breakdowns (grounding of flights) (5) Loss of revenue and (6) Closure of markets (cancellation of weddings, parties, and non-essential retail stores such as florists). The mentioned effects have threatened business continuity (KFC, 2020b). Hence, measuring the fragility of the sector is of interest. Jordaan, (2017) proposed the yard stick to measure the impacts of fragility as to whether an event threatens business continuity or not, defined as the capability

of an organisation to continue the delivery of products or services at pre-defined acceptable levels following a disruptive incident (ISO, 2012).

6.1.2 Steps in measuring cut flower fragility

Survey questions were drawn from literature on fragility analysis methodologies of Jordaan, (2017) . In our case the concept of threat to business continuity per fragility factor was analysed using twelve (12) fragility factors critical to the cut flower chain. The process was as follows; (1) The survey questions measured the worsening of an indicator (fragility factor) on a scale of 0-100% where respondents were asked to quantify the percentage of worsening of a factor on business continuity during the lockdown period starting March 2020. (2)Fragility per factor was calculated by measuring the deviance using Jensen's inequality formula. (3) A polygon was drawn with index values of each fragility factor mapped out.(4) The polygon was then divided into triangles whose area demonstrate the fragility per factor. Hence, the total area of the polygon demonstrated the overall extent of fragility of each actor. (5)Thereafter the individual scores per actor were added into a composite index that demonstrates overall chain fragility (Gopal & Thakkar, 2015). This method of analysis has been successfully used to measure value chain fragility by (Gopal & Thakkar, 2015; Jordaan, 2017; Jordaan & Kirsten, 2019; Setene & Jordaan, 2021).

An unequal variance *t*-test was used to test whether the average fragility of chain actors with different levels of interdependency among their chain players.

The null hypothesis: *There is no statistically significant difference in the average chain fragility of the among actors with different levels of dependencies.*

The alternative hypothesis: *There is a statistically significant difference in the average chain fragility among actors with different value chain dependencies*.

6.2 Change in export value March-April 2019 to March-April 2020

To further understand the impact of the lockdown policy, this research was keen to examine the underlying factors that influenced a change in export value of flowers among different exporters during the lockdown period using an ordered logit model. The change in value of exports of different respondents was analysed based on their dependency with buyers, who the main buyers were, the sizes of the farm and their relationship with input suppliers. The change in export value variable was split into 5 categories; (No change in value = 0 , Loss by less than 25% =1, Loss between 25-50% =2, Loss by 50-75% =3, Over 75% loss =4).

The study employed an ordered logit model, in which the probability of observing an outcome j is written as:

Equation 2: $$\Pr[y_i=j]=F(\alpha_j-\beta'x_i)-F(\alpha_{j-1}-\beta'x_i)$$

where i is the index of individual respondents, j is the index of choices (=0, 1, ..., 4), α is the threshold parameter, x is set of explanatory variables, and F is the cumulative logistic function. The vectors of α and β parameters were then estimated through the maximization of the log-likelihood function.

The null hypothesis *Ho: There is no relationship between change in export value and dependency with buyers, who the main buyers were, the sizes of the farm and their relationship with input suppliers.*

Ha: *There is a relationship between change in export value and dependency with buyers, who the main buyers were, the sizes of the farm and their relationship with input suppliers.*

6.3 Target respondents and sampling

The research targeted actors in the cut flower chain in Kenya spread across the Rift Valley, Central and Nairobi counties in Kenya. They were grouped into four categories, namely: (1) Input suppliers included fertilizer, chemical, seedlings and all farm input providers, (2) Flower farmers included smallholder, medium-scale, and large-scale farmers, (3) Consolidators included middlemen, agents, informal merchants and (4) Exporters to various destinations around the globe. Using the Cochran formula to calculate a representative sample for a finite population (Statistics, 2017), the study targeted to reach one hundred actors in the cut flower chain.

The cut flower sector is a highly privatised and competitive sector hence difficult to access. Therefore, the study used an industry gatekeeper, an officer from the Horticultural Development Authority to recruit and introduce the student to potential respondents. Through purposive sampling, specific respondents were targeted, thereafter they were able to recommend other actors in the chain to participate in the study through snowballing. The respondents were mainly middle level management in their respective organizations in the chain. They were contacted by various means including phone calls, emails, and WhatsApp messages. A short introductory note from the HCDA officer and a link to the questionnaire was sent by the student. Overall, 106 contacts were made. Emails had the lowest response rate with more than

half nil responses, even after follow-up emails were made days later. WhatsApp messages and calls proved to be more efficient in reaching the respondents.

In the end the study was able to achieve a 55% response rate. The distribution of respondents was as follows: 6.6% of respondents were input suppliers, 47.7% were flower farmers, 7.7 % were consolidators and 38.5% were flower exporters, *(n=91)* (figure 6). Due to limitations in number of respondents in the input supplier and consolidator category, a Monte Carlo analysis was run with 100 iterations to provide an accurate score during analysis (Metropolis et al., 2016).

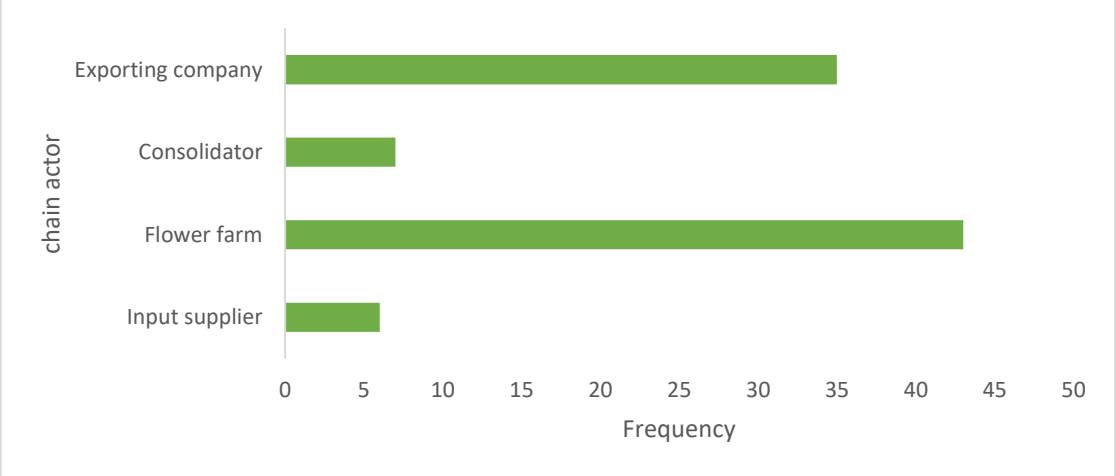


Figure 6: Distribution of respondents across value chain actors

6.4 Methods of data collection

The research constructed a questionnaire using previously standardized questions adopted from literature of (Jordaan, 2017; Lin & Zhang, 2020). A quantitative survey was conducted using a structured questionnaire which was administered online through the kobo toolbox data collection kit. Due to the complexity of some questions, a telephone interview was conducted concurrently sometimes translated to the native

Swahili language to further explain the questions, probe, and ensure accurate response of the online survey. In the end, the questions asked were similar in the online questionnaire and the phone interviews. The data collection was conducted over a period of three months by the student and a volunteer.

7 Results

7.1 Descriptive analysis

The descriptive statistics for continuous variables showed that the average land size under cut flower production among respondents was twenty-four acres, with an average of (248) workers operating per farm. On average each farm harvested approximately 32,000 stems of flowers per day (table 3).

Table 3: Descriptive statistics based in interviews with actors in the sector (n=55)

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Farm size (acres)	4	80	24.04	19.14
Number of employees	10	2500	258.27	488.99
Stems harvested/day	500	280000	31889.09	58370.60

More than half of the interviewed farmers were medium-scale producers with a production of between 10-30 acres of flowers. Twenty percent were large-scale producers with over 30 acres under flower production and (22%) were smallholder producers having less than 10 acres under production. The ownership of the farms was queried based on the majority shareholders. Three categories emerged, locally owned, hybrid (mix of local and foreign investors) and foreign owned (Figure 7)

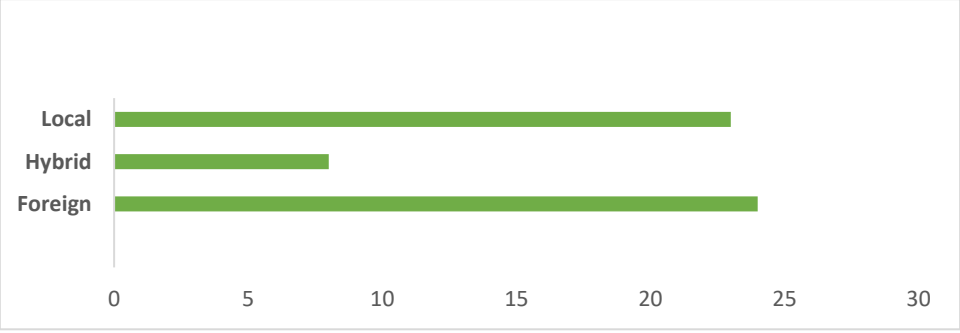


Figure 7: Majority ownership of operations

The main flowers produced were roses (45%), summer flowers (26%) , fillers (22%) and lilies (7%) as shown in (figure 8).

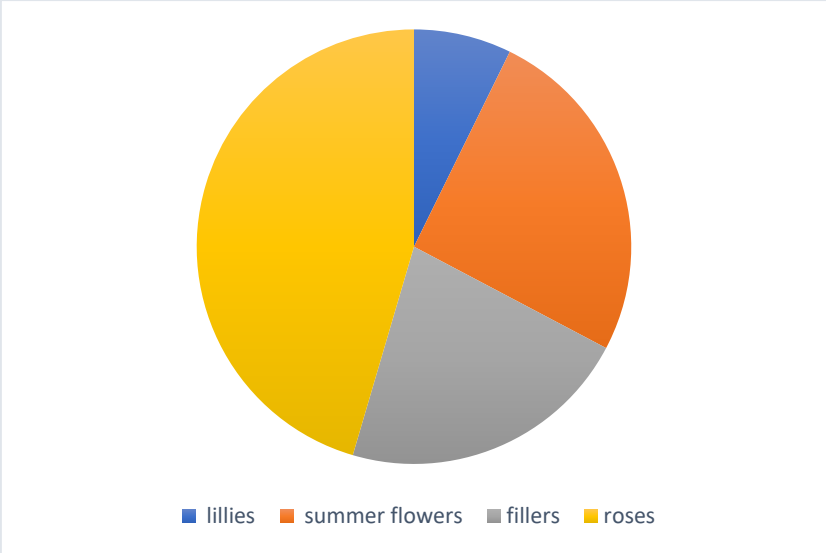


Figure 8: Types of flowers produced

The study confirmed that the market for Kenyan flowers is distributed globally. More than a third of the respondents exported to the Netherlands, a quarter of the respondents exported the United Arab Emirates and (20%) to the United Kingdom. There has been a growth in emerging markets in the gulf states and Asia as seen in (figure 9). Even before the pandemic, flower consolidators and exporters identified the need to diversify markets of the cut flower across continents. As Eastern economies grew from middle income to higher income, consumers in these countries obtained more disposable income to purchase luxurious commodities such as flowers (Assad, 2007).

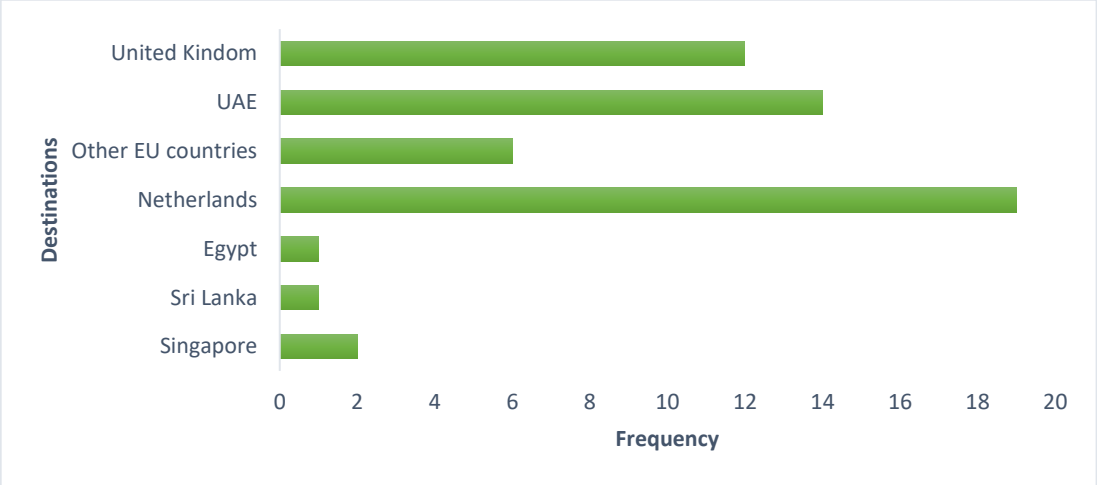


Figure 9: Export destinations amongst interviewed firms

The main buyers of cut flower from Kenya were Dutch auctions (32%), contracts with supermarkets (29%) and agents overseas (33%) (figure 10).

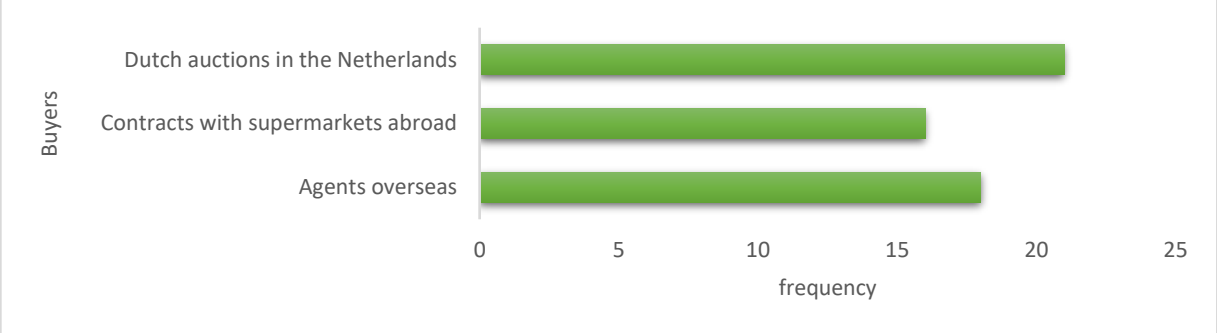


Figure 10: Main buyers as identified by the respondents

7.2 Impact of the lockdown

The study was interested in understanding the impact that the Covid crisis had on the cut flower sector. The percentage of workers sent home at the peak of the lockdown in April 2020 was assessed as a measure of the impact on the labour market. Close to half of the respondents reported sending between 25-50% of their workers home at the said period, while a third reported sending between 50-75% of their workers home

during the lockdown period. Interestingly (7%) of respondents reported as not having sent workers home during the lockdown period (figure 11).

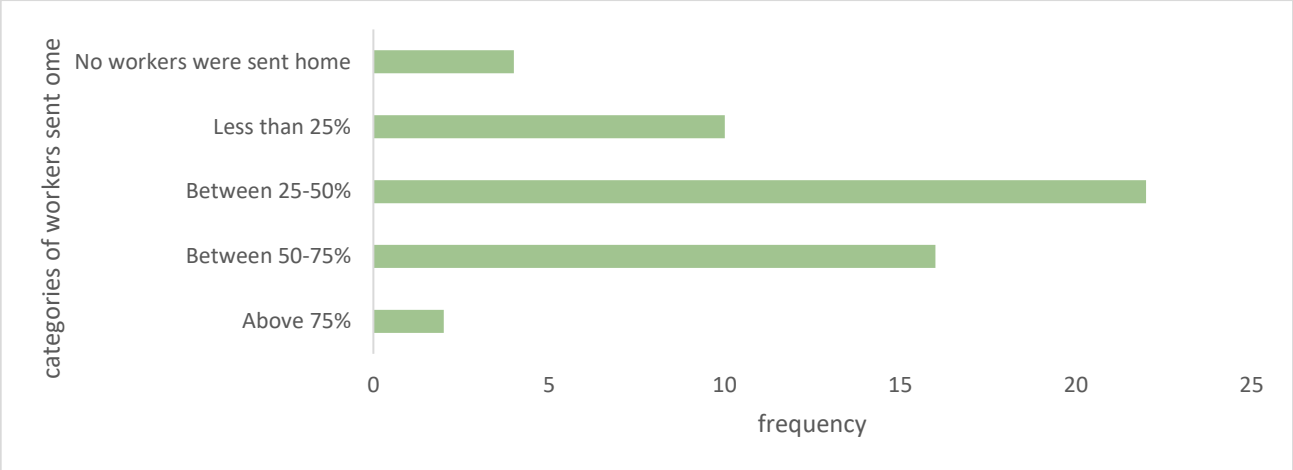


Figure 11: Percentage of workers' sent home reported by respondents

The prices of inputs for flower production and the flowers themselves seemed to have remained fairly stable. More than half of the respondents reported less than 10% increase in price during the same period and another third of respondents reported no change in the price of inputs during the lockdown period.

When probed about the mechanisms that actors adopted to stay afloat during the lockdown period, a third of respondents reported to have cut down operations and a similar amount sent workers home (figure 12), 14% of respondents looked for new markets to export to and a similar number doubled up operations after the lockdown was lifted. Only (2%) of the respondents reported business as usual as seen.

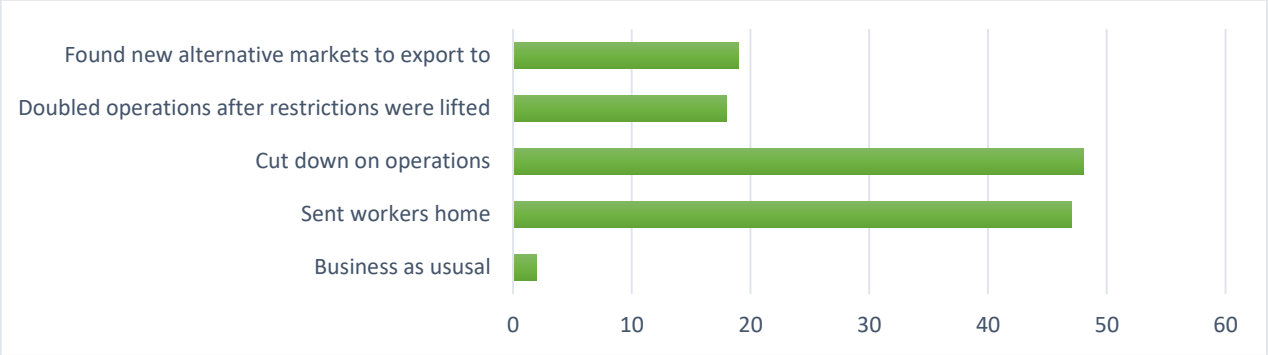


Figure 12: Mechanisms employed by firms to stay afloat

The study also sought to find out the interventions received from the government. More than a third of the respondents reported to have received tax relief and VAT refunds. Twenty percent of the respondents benefited from specialised cargo flights and another (8%) from subsidies (figure 13).

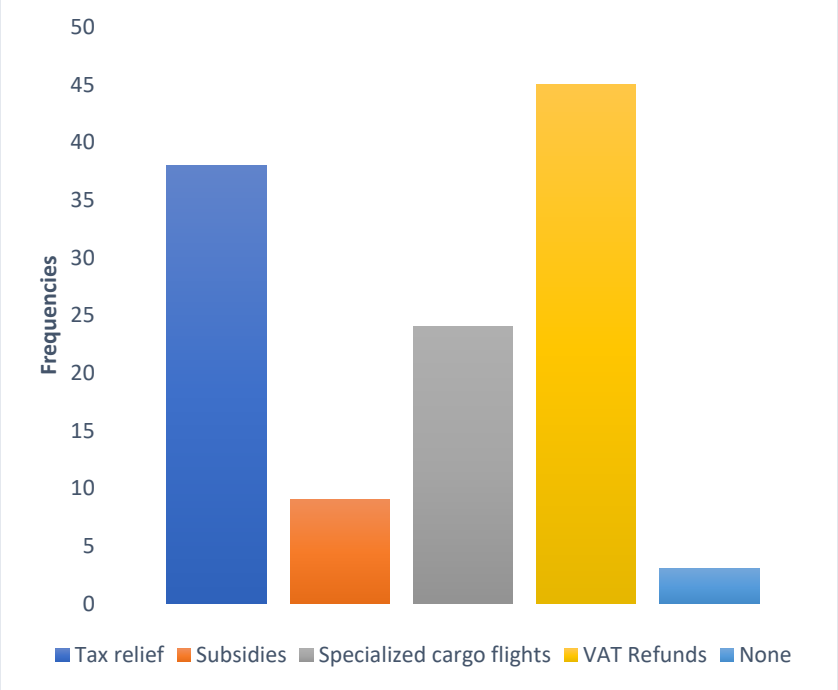


Figure 13: Government interventions during the pandemic as identified by the respondents

A majority of the actors were able to resume normal operations within 1 to 3 months after the lockdown. Interestingly though, there are still a staggering number of actors who have reported as having not gone back to full operations further demonstrating the contrast of experience among actors in the cut flower chain (figure 14).

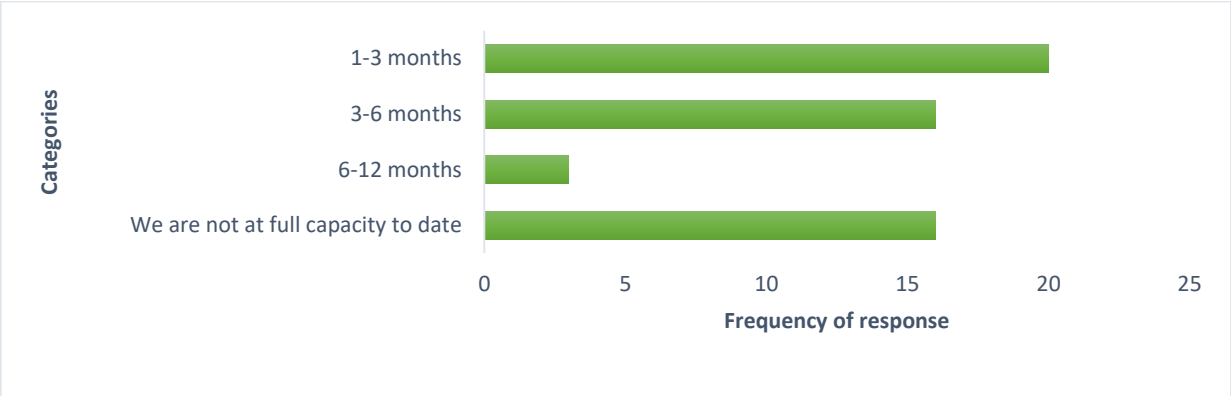


Figure 14: Period to full operations as identified by the respondents

7.3 Cancellation of orders versus dependency of buyers

To further link levels of dependencies and fragility, the study was interested in finding out if the level of dependency with buyers, and hence the involvement in the value chain, had any impact on the cancellation of orders. The null hypothesis tested was whether *there is no significant difference in the cancellation of orders among categories of buyer dependencies*. A cross tabulation was conducted between the two variables and results are in (table 4)

Table 4: Cross tabulation of cancellation of buyers versus dependency of buyers

CROSSTABS		**Level of dependency with your buyers**					
Percentage cancellation of orders		Not dependent	Somewhat dependent	Slightly dependent	Very dependent	Extremely dependent	Total
No cancellation of orders	Count	0	1	0	0	0	1
	Expected Count	0	0.10	0.10	0.20	0.50	1
	% Cancellation	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Cancellation by less than 25%	Count	0	0	0	3	7	10
	Expected Count	0.20	1.50	1.30	2.40	4.70	10
	% Cancellation	0.00%	0.00%	0.00%	30.00%	70.00%	100.00%
Cancellation by 25-50%	Count	0	1	0	4	12	17
	Expected Count	0.30	2.50	2.20	4	8	17
	% Cancellation	0.00%	5.90%	0.00%	23.50%	70.60%	100.00%
Cancellation by 50-75%	Count	1	4	3	5	7	20
	Expected Count	0.40	2.90	2.50	4.70	9.50	20
	% Cancellation	5.00%	20.00%	15.00%	25.00%	35.00%	100.00%
Over 75% orders cancelled	Count	0	2	4	1	0	7
	Expected Count	0.10	1	0.90	1.70	3.30	7
	% Cancellation	0.00%	28.60%	57.10%	14.30%	0.00%	100.00%
Total	Count	1	8	7	13	26	55
	Expected Count	1	8	7	13	26	55
	% Of Total	1.80%	14.50%	12.70%	23.60%	47.40%	100.00%
Chi Square Statistics 33.102 ***							

Note: *** 1% level of significance

The results of the cross tabulation demonstrated that the firms that indicated to be extremely dependent and very dependent reported higher observed values in cancellation of orders than expected, while the less dependent categories reported lower values in cancellation of orders than expected. The Pearson Chi-Square value was reported significant at 1% level of significance thus we rejected the null hypothesis that there is no significant difference in cancellation of orders among chain actors with different levels of dependencies with buyers. This informs us that firms who depended highly on a few buyers were more affected with higher percentage cancellation of orders than firms that had a diversified portfolio of buyers for their produce.

7.4 Change in export value March-April 2019 to March-April 2020

The ordered logistic regression analysis investigated the change in value of exports, which was measured by comparing the export value of similar volumes of flowers during the period of March - April 2019 and March - April 2020. There were 5 categories (No change in value=0, Loss by less than 25%=1, Loss by between 25-50%=2, Loss by 50-75%=3, Over 75% loss=4). The resulting distribution of responses was as follows (figure 15);

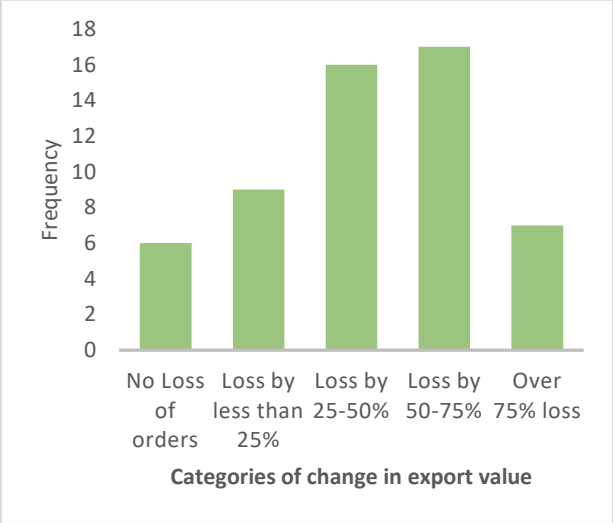


Figure 15: Change in export value from a period of March-April 2019 vs. March - April 2020

The change in export value was measured against dependency with buyers, who the main buyers were, the sizes of the farm in acres, and their relationship with input suppliers. The level of dependency variable was measured based on the three classifications of chain dependencies, pooled, sequential, channel or reciprocal dependencies (Kembro and Selviaridis, 2015) as previously described in the literature with former classifications indicating lower levels of dependencies (Not dependent, slightly dependent, somewhat dependent) and the latter indicating higher dependencies (Very dependent, extremely dependent).The results are given in table 5.

Table 4: Results of the ordered regression analysis on change in value of exports

Coefficients:			
	Value	**Std. Error**	**t value**
Dependency with buyers	-0.9125	0.4936	-1.8487**
Main buyers	-0.5356	0.3581	-1.4958**
Farm size (acres)	0.2507	0.9046	0.2771
Relationshipwithinputsupplier	-0.5554	1.3040	-0.4259

Note ** 5% level of significance

Residual Deviance: 70.27163

The coefficients show that a unit increase in dependency with buyers leads to a decreased in export value 0.19. The output shows that the change in export value was affected by dependency of buyers and the main buyers at 5% level of significance. Thus, we rejected the null hypothesis that there is no relationship between change in export value and level of dependency of buyers and who the main buyers of the flowers were. The results of the analysis showed that change in export value was affected by who the main market of the flower commodity was. Producers that depended on concentrated buyers in European market got higher cancellations than those that had various agents in different continents. This could be attributed to the fact that Europe was the first continent to be hard hit by the pandemic outside China (Floral daily, 2020). In the same way actors with higher levels of interdependencies observed higher levels of cancellation than expected in the cross-tabulation analysis. Thus, further cementing our findings that higher chain dependencies lead to higher fragility.

7.1 Fragility analysis

In the process of measuring the fragility, survey questions measured the worsening of an indicator (fragility factor) on a scale of 0-100% , which was then coded to numbers 1-9. The means, max and minimum values of these outputs were computed, then fragility scores were calculated by measuring the deviance from linearity using Jensen's inequality formula. Table 6 presents the factors that scored highest in fragility across the whole chain. Quality performance and laws and regulations score highly across the board. Higher negative fragility scores indicate higher fragility of a factor(Jordaan & Kirsten, 2019).

Table 5: Results of fragility scores of factors with the highest scored the survey

	Fragility Factor	**Fragility score**
Input suppliers	Buyer relationship	-2.50
	Chain complexity	-2.00
	Laws and regulation	-1.00
	Quality performance	-3.60
Farmers	Buyer relationship	-5.60
	Chain complexity	-3.89
	Laws and regulation	-5.06
	Quality performance	-6.30
Exporters	Buyer relationship	-6.21
	Chain complexity	-3.70
	Laws and regulation	-4.84
	Quality performance	-5.86
Consolidators	Buyer relationship	-5.86
	Chain complexity	-3.43
	Laws and regulation	-3.93
	Quality performance	-4.50

The total fragility scores were mapped out (figure 16). From the output it is clear that flower farmers face the highest fragility, followed by exporters then finally consolidators. Input suppliers were not considered fragile as they serve other agricultural sectors. This can be explained by the fact that the farmer always bears the greatest risk in any supply chain (Ricketts et al., 2014) . Consolidators score low on fragility because they are free to source from any farm and have non binding contracts with international agents.

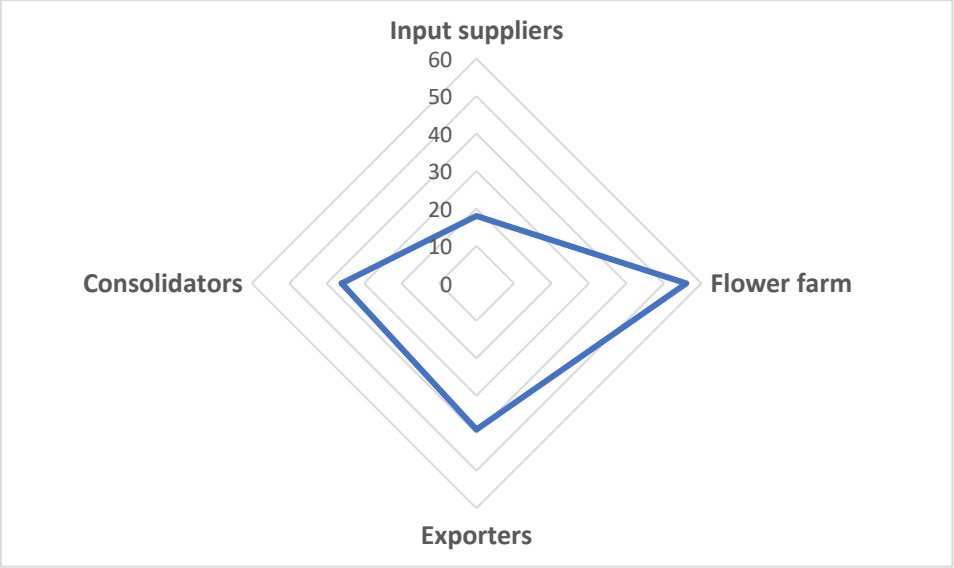


Figure 16: Total fragility scores in the cut flower chain

The study also mapped out the fragility scores separately between lower (pooled and sequential dependencies) and higher levels (reciprocal and channel) of dependencies

to determine whether different levels of interdependencies led to different fragility factors being critical (figure 17) .

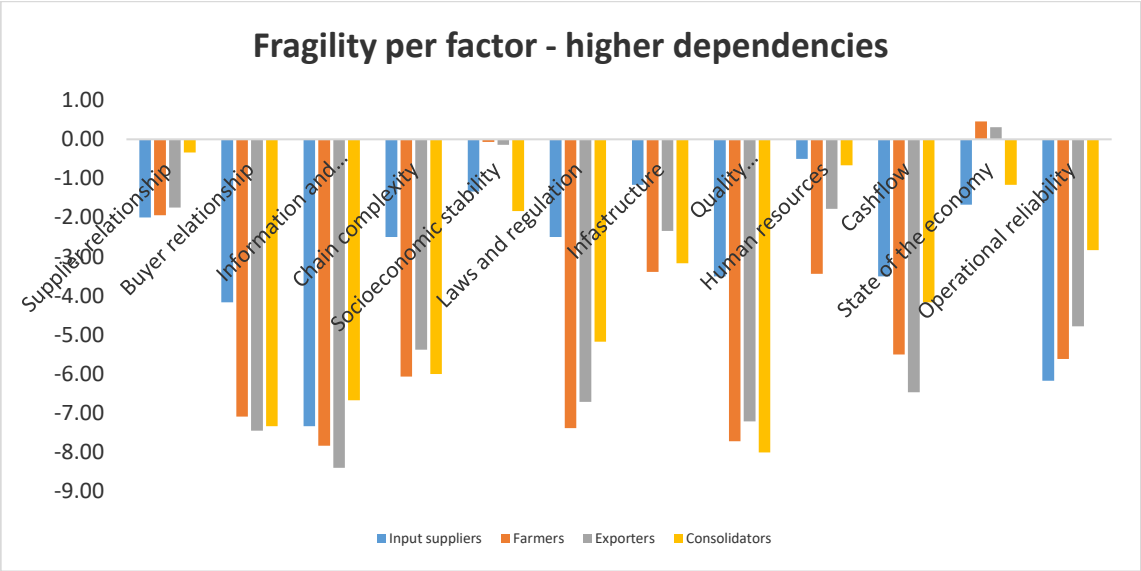


Figure 17: Fragility of factors affecting chain players with higher dependencies

The scores on eleven out of the twelve fragility factors were negative in this category therefore demonstrating that the cut flower chain is indeed fragile in these aspects. Buyer relationship and operational reliability scored highly, while state of the economy was less scored for chains with higher dependencies. The study also mapped out fragility scores of actors with lower levels of dependencies (figure 18).

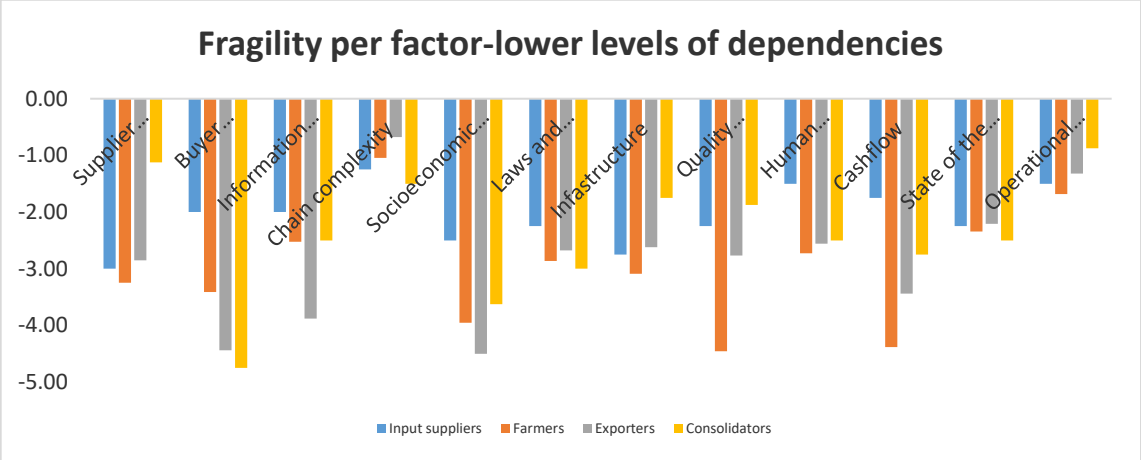


Figure 18: Fragility of factors affecting players with lower levels of dependencies

All twelve factors were fragile for the lower levels of interdependencies, though with a lower fragility score. This demonstrates that the lower dependencies are less fragile.

For a clearer picture of the critical factors among producers and exporters, the results of the fragility scores calculated and presented above were mapped out for flower farmers with different levels of fragility (figure 19). Buyer relationships, information and communication, laws and regulations and quality performance were key for flower farms with higher levels of dependencies. The state of the economy, quality, and product performance and cashflow were key for farmers with lower levels of dependencies.

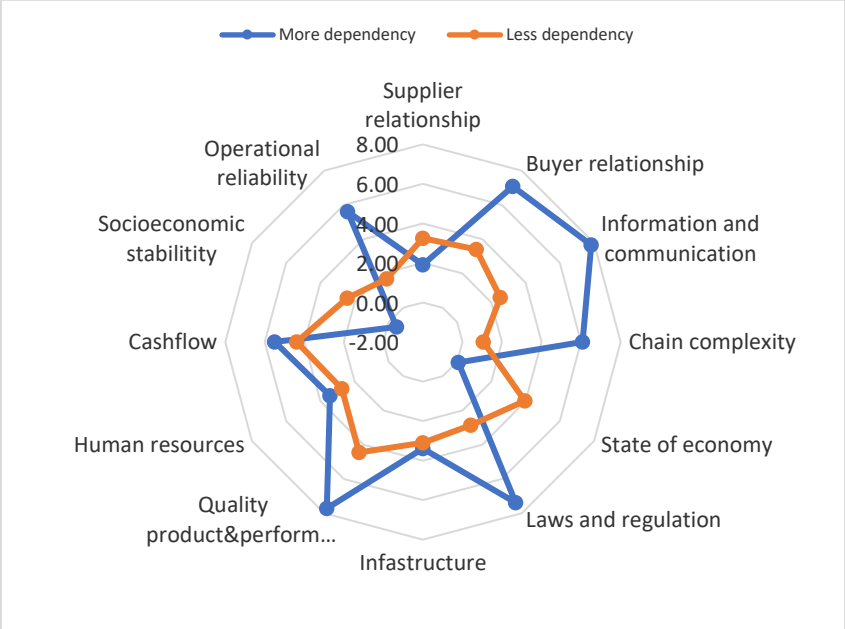


Figure 19: Mean fragility of flower farmers with different levels of dependencies

Cashflow, information and communication, laws and regulations and quality and product performance were key for exporters with higher levels of dependencies while the scores of state of the economy, information, and communication and cashflow were higher for exporters with lower levels of interdependencies (figure 20).

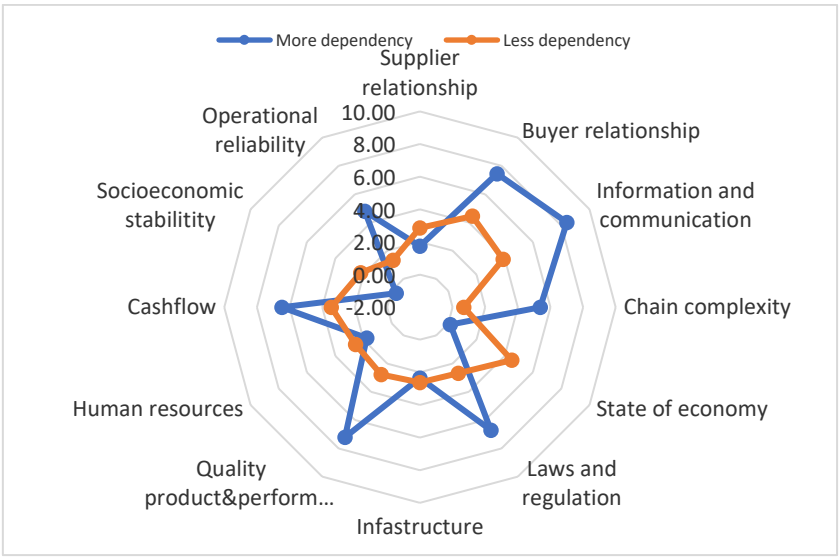


Figure 20: Mean fragility of exporters with different levels of dependencies

The results of one unequal variance two tailed *t*-tests used to test whether the mean fragility scores of the actors with two different levels of dependencies resulted in a significant value of (p=0.01). We were thus confident to reject the null hypothesis that there are no significant differences in fragility scores between chain actors with different levels of chain dependencies. These finding demonstrates that fragility is in fact affected by the level of dependency among actors in the chain.

8 Discussion

The results of this study point to an interesting case of a value chain with high fragility scores. The premise of our research was that the fragility of a chain is in fact affected by its choice of chain coordination mechanisms.

To set the scene, we describe the types of operations in the flower sector that were found in the study. One, the highly vertically integrated actors with higher dependencies were found to be foreign owned operations. In these cases, entrepreneurs with a footing in the European flower market entered into Kenya's flower production business by leasing out land and setting up production operations. In an act of value capture, one or two organizations were in charge of the production, export, and wholesale. Most of the operations were resource endowed and operated in a large scale with over 50 acres under production, the focus was on roses and their main market the Dutch auctions and own wholesales with fixed contracts. On the other hand, there were mediumly integrated actors that consisted of medium-scale producers operating with a diversified portfolio of both roses, summer flowers and filler flowers production. They were a mix of local and foreign owned operations. These actors mostly had contracts with supermarkets in the UK and Germany and Dutch auctions. The levels of dependencies were much lower and different companies handled different aspects of the operations. Finally, there was a group of operators with lowest levels of interdependencies. These consisted of smallholder farmers mostly producing summer flowers and filler flowers. These actors had no direct access to export markets and depended on consolidators to collect and sell their flowers. The

consolidators would have short term contracts with overseas agents in various countries and were in constant search for new markets.

It was interesting to observe similarities in key fragility factors among chain players despite the chain coordination mechanism used. Quality and safety performance ranked higher in fragility scores by producers, exporters, and consolidators with various levels of interdependency. The findings corroborate studies by Teixeira,(2003) who in his analysis of post-harvest requirements of cut flowers describe critical requirements of upholding flower quality. Their studies provide guidelines on the processes of handling, grading and storage of cut flowers for maintenance of quality beyond the consumers' purchase date. The act of cutting the flowers days before it arrives to the consumer makes it delicate hence it is imperative to maintain its pristine condition (Nowakowska & Tubis, 2015). The sector exalts quality as a critical aspect of its operations. Consumers demand longevity of intrinsic qualities including scent, colour, floral head size and vase life (Oppenheim, 1996).

The findings that safety performance scored highly in the fragility score was consistent with literature. The flower business is among the most standardized sectors. It comprises of specific requirements that encompass protocols in production, post-harvest handling, fertilizer and pest management (Wainwright & Labuschagne, 2009). Rigorous inspections are conducted on pesticide residue levels with the key markets like the EU fixing the maximum residue levels at analytical zero (GLOBAL GAP, 2019) .

Laws and regulations were reported as highly fragile across the board. The cut flower sector is known to enforce several certification processes for achievement of

international standards of compliance. EUREPGAP standards are required for entry into EU markets (EurepGAP, 2004) phytosanitary standards are enforced by the Kenya Plant Health Inspectorate at port of exit (KEPHIS, 2021), and social certifications such as Fairtrade aid in the acceptance of the commodity into mainstream market (Fairtrade, 2013). The findings that laws and regulation have high fragility scores is in line with several studies including Nelson & Tallontire, 2014; Ouma, 2010; Riisgaard, 2009; Asfaw et al., 2010 continue to criticize the ever changing regulations in the flower sector. They extensively analysed the regulations in private standards certifications and raised an alarm on the increasing number of and constant change in requirements of private standards in the sector. Riisgaard, (2009) reported that the constant introduction of new standards created a lack of clarity around the production requirements, while Nelson & Tallontire, (2014) questioned who the standards truly serve. Several studies recommended the harmonization of private standards for reduced uncertainty on market requirements (Ouma, 2010; Riisgaard, 2009).

Another factor with high fragility scores among all chain actors was the relationship with buyers. This encompasses the business culture, ethics, trust, goals, duration, and quality of relationship. These findings were in line with studies by MacChiavello & Morjaria, (2015) who analysed the value of relationships amongst chain actors with evidence from flower production in Kenya. The study emphasized the importance of an actor's reputation among colleagues and highlighted buyer belief as key in accessing markets. The study suggested fostering good relationships with buyers as key in maintaining markets.

As anticipated, there were some struck contrasts among respondents on key fragility factors based on their value chain coordination mechanisms. Chain actors with higher levels of dependencies ranked chain complexity with a higher fragility scores than their counterparts. These findings were validated by studies done by (Setene & Jordaan, 2021; Wever et al., 2012a) who contended that the more complex the chain the more fragile it was. They explained that increasing the number of links, number of actors, number of products and destinations of products exacerbates the fragility of the sector.

Chain players with higher levels of dependencies scored less on fragility scores when social stability and the state of the economy were probed compared to players with lower levels of dependencies. This is in line with literature from Bolo, (2010) who conducted extensive studies on types of ownership of flower operations demonstrating the vast contrast of experiences in the flower sector based on ownership. Smallholder operations face specific challenges while foreign owners are sometimes shielded from some local experiences and challenges. To foreign owned operations, the socioeconomic issues would not be as risky a factor as a local smallholder producer who depends on the state of the economy and social stability for success of their operations.

The pandemic offered the opportunity to test the performance of fragility factors. The lockdown policy was catastrophic to the sector as it heavily relies on air cargo for logistics. Europe was the first continent to be severely hit by the pandemic outside China, hence its lockdown disrupted the main market for Kenya's cut flower. The study

findings reported the cancellation of orders of up to 75% by a third of respondents. This was as a result of the breakdown of logistical flow of goods. Both air cargo and restricted movement of trucks across regions due to the lockdown policy crippled flow of the commodity. There was a high demand for cargo space among the few remaining operators which led to a doubling of the cost of cargo space (KFC, 2020a) The closure of a majority of retail outlets for cut flowers including florists, open air markets coupled with the cancellation of social events such as weddings caused massive loss of markets (Union Fleurs, 2021). The study found that more than two thirds of the respondents sent more than half of their workers home at this time. Although some actors reported as asking their in-office operations employees in higher levels of management to take all their leave days, in most cases the field labourers with causal contracts who were mostly women, were sent home without any reprieve (HIVOS, 2020). The results also reported a loss of revenue of between 50-75% among a third of their respondents. With no markets to sell to, most respondents reported to have buried their produce for creation of compost fertilizer.

The findings of the ordered logistic regression analysis showed that change in export value was affected by who the main market of the flower commodity was. And levels of dependencies. Higher levels of interdependencies observed higher levels of cancellation than expected in the cross-tabulation analysis (table 4). Thus, further cementing our findings that higher chain dependencies lead to higher fragility.

In terms of government intervention, more than a third of the respondents reported to have received tax relief throughout the year and value added tax refunds. A

suspension in taxes on inputs was also reported as a subsidy given by government and an extended grace period was negotiated with lenders. Thus, the institutional frameworks stepped up and proved to be anti-fragile in this period.

Half of the respondents reported to have gone back to almost full operations within the first three months. These were mostly the vertically integrated actors accessing European markets. This can be attributed to the government and private sector efforts to rescue the sector, further pointing to anti-fragility of institutional frameworks. The Kenyan government converted its passenger flights into cargo flights to ease the pressure on cargo space (Business daily, 2020). At the same time, information on the epidemiology of the virus and management guidelines from WHO aided in the recovery of the sector. Most flower farms provided sufficient protective equipment to restore worker safety and motivation in the greenhouses, grading, packing, cooling, and processing facilities. They introduced protocols and contingency measures in case of detection of a COVID-19 (Floral daily, 2020). Interestingly, the remaining respondents that reported as having not gone back to full operations to date were mostly consolidators and small-scale flower producers that depend on connections with agents overseas. This clearly point back to the disparities among local and foreign owned operations in terms of access to resources rather than levels of fragility. In fact, non-integrated operations proved to be less fragile as their non-binding contracts enabled them to explore emerging African markets, especially in Egypt and others in the middle and far East.

9 Conclusion

This study has empirically analysed the fragility of the cut flower sector in Kenya and impacts of the lockdown policy. Using a heuristic stress test approach, it has measured the deviance from linearity across different levels of deterioration of a factor and revealed the critical factors that cause fragility in the cut flower chain in Kenya. Overall, eleven of the twelve factors proved fragile, therefore indicating an overall fragile chain. Moreover, the measured factors were affected at different levels for different actors and different levels of dependencies. This demonstrates the unique set of circumstances faced by each role in the chain hence the need for differentiated strategies in operations. Findings from the study lead to a conclusion that that there exists an overall trade-off between chain performance and levels of vertical integration.

The COVID-19 pandemic offered the opportunity to measure the fragility of the sector in Kenya. The findings of our studies showed that buyer relationships, laws and regulations, logistics, human resources and cashflow as the critical factors that proved fragile when hit by this atypical event. Overall, the cut flower sector proved to be resilient as a majority of chain actors bounced back three months after the first lockdown.

The results of this study have key policy implications. The Kenyan government should intervene in small and medium-scale flower operators and address the issues that cause their fragility through improving the infrastructural capacity including roads from farm to port of exit, providing pack houses, cold chain logistics for rent at

affordable rates especially at the port of exit. The government should also ensure socioeconomic stability as local actors depend on the enabled business environment, strong value of the currency against the dollar, interest rates, economic growth rate, and overall stability for ease of doing business.

Harmonized of laws and regulations is key for operations in the sector. To address the outcry of producers and exporters on multiple regulations, the Kenyan government could spearhead the use of Institutional frameworks to find solutions. This would be led by the Horticultural development authority and private sector including The Kenya flower council and Fresh producers and exporters association. The process would prioritize creation of an policy proposal for harmonization of the sector through a multi-institutional and multi stakeholder taskforce. Recommendations from the taskforce could then be implemented through a government mandate.

There is a need for incubation of locally owned start-up operations to ensure globally competitiveness. Findings of the study confirm the need to diversify markets outside traditional outlets in Europe so as to spread out risks and increase Kenya's share in the global trade.

In summary, this analysis has provided an opportunity to advise cut flower chain actors on how best to secure their investment in the wake of unpredictable events. The results of the study are important to guide the design of complementary policy measures to mitigate the negative effects of atypical events such as the pandemic lockdown measures.

Further studies can be done to recommend the best balance between chain coordination strategies in the cut flower sector that will meet the unique objectives of a faraway market while maintaining autonomy of each actor in this chain.

10 References

Aday, S., & Aday, M. S. (2020). Impact of COVID-19 on the food supply chain. *Food Quality and Safety*, *4*(4), 167–180. https://doi.org/10.1093/fqsafe/fyaa024

Adeola, O., Meru, A. K., & Kinoti, M. W. (2018). Kenya's Blooming Flower Industry: Enhancing Global Competitiveness. *Africa's Competitiveness in the Global Economy*, 331–349. https://doi.org/10.1007/978-3-319-67014-0_13

Asfaw, S., Mithöfer, D., & Waibel, H. (2010). What impact are EU supermarket standards having on developing countries' export of high-value horticultural products? Evidence from Kenya. *Journal of International Food and Agribusiness Marketing*, *22*(3), 252–276. https://doi.org/10.1080/08974431003641398

Assad, S. W. (2007). The rise of consumerism in Saudi Arabian society. *International Journal of Commerce and Management.*

Bolo, M. O. (2010). Learning to export: building farmers' capabilities through partnerships in Kenya's flower industry. *Cirad-Inra-SupAgro*, 1–12. http://hal.archives-ouvertes.fr/docs/00/52/61/45/PDF/Bolo_Learning_to_export.pdf

Business daily. (2020). *Cargo freight can lift KQ - Business Daily*. https://www.businessdailyafrica.com/bd/opinion-analysis/editorials/cargo-freight-can-lift-kq-3278540

Chege, J. (2012). *Value Addition in Coffee Industry in Kenya : Lessons from Cut Flower Sector By Kenya Institute for Public Policy Research and Analysis (KIPPRA) Nairobi , Kenya*. *ICBE-RF Research Report*, 42.

D. Ricketts, K., G. Turvey, C., & I. Gómez, M. (2014). Value chain approaches to development. *Journal of Agribusiness in Developing and Emerging Economies*, *4*(1), 2–22. https://doi.org/10.1108/jadee-10-2012-0025

Den Ouden, M., Dijkhuizen, A. A., Huirne, R. B. M., & Zuurbier, P. J. P. (1996). Vertical cooperation in agricultural production-marketing chains, with special reference to product differentiation in pork. *Agribusiness*, *12*(3), 277–290. https://doi.org/10.1002/(SICI)1520-6297(199605/06)12:3<277::AID-AGR7>3.0.CO;2-Y

EurepGAP. (2004). *General Regulations* (Issue July).

Fairtrade. (2013). *FAIRTRADE mark guidelines* (Issue 2). http://fairtradeindia.org/wp-content/uploads/2013/12/2013-11-21_Press-Release_Media-Introduction-

Fairtrade-India.pdf

Fairtrade. (2021). *What Is Fairtrade – Fairtrade Africa*. https://fairtradeafrica.net/what-is-fairtrade/

Floral daily. (2020). *What should growers do? COVID-19 considerations*. https://www.floraldaily.com/article/9202244/what-should-growers-do-covid-19-considerations/

FPEAK. (2021). *Services – Fresh Produce Exporters Association of Kenya*. https://fpeak.org/our-services/

Gaonkar, R. S., & Viswanadham, N. (2007). Short Papers of Risk in Supply Chains. *Ieee Transactions on Automation Science and Engineering*, *4*(2), 265–273.

Gemählich, G. (2017). Africa Spectrum Sustainability and Depoliticisation : *GIGA German Institute of Global and Area Studies,* 31–53. http://nbn-resolving.org/urn:nbn:de:gbv:18-4-10783

Gereffi, G. (1996). Global Commodity Chains: New Forms of Coordination and Control among Nations and Firms in International Industries. In *Competition & Change* (Vol. 1, Issue 4, pp. 427–439). https://doi.org/10.1177/102452949600100406

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. *Review of International Political Economy*, *12*(1), 78–104. https://doi.org/10.1080/09692290500049805

GLOBAL GAP. (2019). *GLOBALG.A.P. in Africa - Figures and Facts*. https://www.globalgap.org/de/newsartikel/GLOBALG.A.P.-in-Africa-Figures-and-Facts/

Gopal, P. R. C., & Thakkar, J. (2015). Development of composite sustainable supply chain performance index for the automobile industry. *International Journal of Sustainable Engineering*, *8*(6), 366–385. https://doi.org/10.1080/19397038.2014.947392

Govoni, N. A. (2012). Complimentary Copy. *Dictionary of Marketing Communications*, *12*(2). https://doi.org/10.4135/9781452229669.n742

Growth, C. (n.d.). *IN*.

Hale, A., & Opondo, M. (2005). Humanising the cut flower chain: Confronting the realities of flower production for workers in Kenya. *Antipode*, *37*(2), 301–323.

https://doi.org/10.1111/j.0066-4812.2005.00494.x

Hart, C. (2020). *Nine in 10 supply chains hit by coronavirus*. Supply Management. https://www.cips.org/supply-management/news/2020/march/nine-in-10-supply-chains-hit-by-coronavirus/

HCA. (2021a). *Overview*. http://horticulture.agricultureauthority.go.ke/index.php/sectors/overview

HCA. (2021b). *Regulations and Compliance*. http://horticulture.agricultureauthority.go.ke/index.php/our-services/licensing-and-regulation

HIVOS. (2020). *Impact of Covid-19 on Women Workers in the Horticulture Sector in Kenya*. *April*, 1–40.

Hobbs, J. E. (2020). Food supply chains during the COVID-19 pandemic. *Canadian Journal of Agricultural Economics*, *68*(2), 171–176. https://doi.org/10.1111/cjag.12237

Hoek, R. van. (2020). Responding to COVID-19 Supply Chain Risks—Insights from Supply Chain Change Management, Total Cost of Ownership and Supplier Segmentation Theory. *Logistics*, *4*(4), 23. https://doi.org/10.3390/logistics4040023

Hughes, A. (2000). Retailers, knowledges and changing commodity networks: The case of the cut flower trade. *Geoforum*, *31*(2), 175–190. https://doi.org/10.1016/S0016-7185(99)00034-2

ISO. (2012). *ISO 22301:2012(en), Societal security — Business continuity management systems --- Requirements*. https://www.iso.org/obp/ui/#iso:std:iso:22301:ed-1:v2:en

Ivanov, D. (2020). Predicting the impacts of epidemic outbreaks on global supply chains : A simulation-based analysis on the coronavirus outbreak. *Transportation Research Part E*, *136*(March), 101922. https://doi.org/10.1016/j.tre.2020.101922

Jira, C., & Toffel, M. W. (2013). Engaging supply chains in climate change. *Manufacturing and Service Operations Management*, *15*(4), 559–577. https://doi.org/10.1287/msom.1120.0420

Jordaan. (2017). *Agribusiness value-chain risk , fragility and coordination strategies : Case studies of South African value chains*. *July*, 164.

Jordaan, D. du P. S., & Kirsten, J. F. (2019). Measuring the fragility of agribusiness value chains: A case study of the South African lamb chain. *International Food and Agribusiness Management Review*, *22*(1). https://doi.org/10.22434/IFAMR2017.0103

Kembro, J., & Selviaridis, K. (2015). Exploring information sharing in the extended supply chain: An interdependence perspective. *Supply Chain Management*, *20*(4), 455–470. https://doi.org/10.1108/SCM-07-2014-0252

Kenya flower council. (2020). *Mitigating the impact of COVID-19 on Kenya's Floriculture Industry*. https://www.floraldaily.com/article/9201565/mitigating-the-impact-of-covid-19-on-kenya-s-floriculture-industry/

KEPHIS. (2021). *Kenya Plant Health Inspectorate Service (KEPHIS)*. https://kephis.org/

Kerr, W. A. (2020). The COVID-19 pandemic and agriculture: Short- and long-run implications for international trade relations. *Canadian Journal of Agricultural Economics*, *68*(2), 225–229. https://doi.org/10.1111/cjag.12230

KFC. (2020a). *"Lack of freight now the major hinderance to Kenya's cut flower export."* https://www.floraldaily.com/article/9208071/lack-of-freight-now-the-major-hinderance-to-kenya-s-cut-flower-export/

KFC. (2020b). *Mitigating the impact of COVID-19 on Kenya's Floriculture Industry*. https://www.floraldaily.com/article/9201565/mitigating-the-impact-of-covid-19-on-kenya-s-floriculture-industry/

KFC. (2021). *OUR HISTORY*. https://kenyaflowercouncil.org/index.php/our-story/our-history

Lin, B. xi, & Zhang, Y. Y. (2020). Impact of the COVID-19 pandemic on agricultural exports. *Journal of Integrative Agriculture*, *19*(12), 2937–2945. https://doi.org/10.1016/S2095-3119(20)63430-X

Linkov, I., Bridges, T., Creutzig, F., Decker, J., Fox-lent, C., Kröger, W., Lambert, J. H., Levermann, A., Montreuil, B., Nathwani, J., Nyer, R., Renn, O., Scharte, B., Scheffler, A., Schreurs, M., & Thiel-clemen, T. (2014). Changing the resilience paradigm. *Nature Publishing Group*. https://doi.org/10.1038/nclimate2227

Ma, L., & Liu, P. (2019). Missing links between regulatory resources and risk concerns: Evidence from the case of food safety in China. *Regulation and Governance*, *13*(1), 35–50. https://doi.org/10.1111/rego.12160

MacChiavello, R., & Morjaria, A. (2015). The value of relationships: Evidence from a

supply shock to kenyan rose exports. *American Economic Review*, *105*(9), 2911–2945. https://doi.org/10.1257/aer.20120141

Mahoney, J. T. (1992). The choice of organizational form: Vertical financial ownership versus other methods of vertical integration. *Strategic Management Journal*, *13*(8), 559–584. https://doi.org/10.1002/smj.4250130802

Maples, J. G., Thompson, J. M., Anderson, J. D., & Anderson, D. P. (2021). Estimating COVID-19 Impacts on the Broiler Industry. *Applied Economic Perspectives and Policy*, *43*(1), 315–328. https://doi.org/10.1002/aepp.13089

Mekonnen, M. M., Hoekstra, A. Y., & Becht, R. (2012). Mitigating the Water Footprint of Export Cut Flowers from the Lake Naivasha Basin, Kenya. *Water Resources Management*, *26*(13), 3725–3742. https://doi.org/10.1007/s11269-012-0099-9

Mentzer, J. T., Keebler, J. S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). JOURNAL OF BUSINESS LOGISTICS, Vol.22, No. 2, 2001 1. *Journal of Business*, *22*(2), 1–25.

Metropolis, N., Ulam, S., Journal, S., Statistical, A., & Sep, N. (2016). *The Monte Carlo Method Published by : Taylor & Francis , Ltd . on behalf of the American Statistical Association Stable URL : http://www.jstor.org/stable/2280232 JOURNAL OF THE AMERICAN*. *44*(247), 335–341.

Morton, J. (2020). On the susceptibility and vulnerability of agricultural value chains to COVID-19. *World Development*, *136*, 105132. https://doi.org/10.1016/j.worlddev.2020.105132

Nchanji, E. B., & Lutomia, C. K. (2021). Regional impact of COVID-19 on the production and food security of common bean smallholder farmers in Sub-Saharan Africa: Implication for SDG's. *Global Food Security*, *29*(February), 100524. https://doi.org/10.1016/j.gfs.2021.100524

Nelson, V., & Tallontire, A. (2014). Battlefields of ideas: Changing narratives and power dynamics in private standards in global agricultural value chains. *Agriculture and Human Values*, *31*(3), 481–497. https://doi.org/10.1007/s10460-014-9512-8

Nowakowska, M., & Tubis, A. (2015). Reliability of the cut flowers' supply chain. *Safety and Reliability of Complex Engineered Systems - Proceedings of the 25th European Safety and Reliability Conference, ESREL 2015*, *December*, 1755–1762. https://doi.org/10.1201/b19094-227

OEC. (2021). *Cut Flowers in Kenya | OEC - The Observatory of Economic Complexity*.

https://oec.world/en/profile/bilateral-product/cut-flowers/reporter/ken?redirect=true

Ouma, S. (2010). Global standards, local realities: Private agrifood governance and the restructuring of the Kenyan horticulture industry. *Economic Geography*, *86*(2), 197–222. https://doi.org/10.1111/j.1944-8287.2009.01065.x

Perry, M. K. (1989). Chapter 4 Vertical integration: Determinants and effects. *Handbook of Industrial Organization*, *1*, 183–255. https://doi.org/10.1016/S1573-448X(89)01007-1

Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring Supply Chain Resilience: Development of a Conceptual Framework. *Journal of Business Logistics*, *31*(1), 1–21. https://doi.org/10.1002/j.2158-1592.2010.tb00125.x

Rapsomanikis, G. (2015). The economic lives of smallholder farmers. *FAO Food And Agriculture Organization of the United Nations*, 39. www.fao.org/publications%0Ahttp://www.macrothink.org/journal/index.php/rae/article/view/6320%0Ahttp://www.upov.int/edocs/mdocs/upov/en/upov_sym_ge_11/upov_sym_ge_11_10.pdf%0Ahttp://ajae.oxfordjournals.org/cgi/doi/10.2307/1241587%0Awww.iosrjournals.org%0Ah

Remko, van H. (2020). Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice. *International Journal of Operations and Production Management*, *40*(4), 341–355. https://doi.org/10.1108/IJOPM-03-2020-0165

Reuters. (2020). *Kenya's flower industry rebounds as lockdowns ease | Reuters*. https://www.reuters.com/article/uk-health-coronavirus-kenya-flowers-idUKKCN24M12Q

Riisgaard, L. (2009). Global Value Chains, Labor Organization and Private Social Standards: Lessons from East African Cut Flower Industries. *World Development*, *37*(2), 326–340. https://doi.org/10.1016/j.worlddev.2008.03.003

Riisgaard, L., & Gibbon, P. (2014). Labour management on contemporary Kenyan cut flower farms: Foundations of an industrial-civic compromise. *Journal of Agrarian Change*, *14*(2), 260–285. https://doi.org/10.1111/joac.12064

Ruan, J., Cai, Q., & Jin, S. (2021). Impact of COVID-19 and Nationwide Lockdowns on Vegetable Prices: Evidence from Wholesale Markets in China. *American Journal of Agricultural Economics*. https://doi.org/10.1111/ajae.12211

Setene, L., & Jordaan, D. (2021). The trade-off between chain performance and

fragility considering coordination strategies of agri-food chains: a South African egg chain's case study. *International Food and Agribusiness Management Review*, *24*(3), 439–461. https://doi.org/10.22434/ifamr2020.0079

Shangquan, G. (2000). Economic Globalization: Trends, Risks and Risk Prevention Contents. *United Nations*, *1*(1), 1–8.

Sharma, R., Shishodia, A., Kamble, S., Gunasekaran, A., & Belhadi, A. (2020). Agriculture supply chain risks and COVID-19: mitigation strategies and implications for the practitioners. *International Journal of Logistics Research and Applications*, *0*(0), 1–27. https://doi.org/10.1080/13675567.2020.1830049

Statista. (2021). • *Kenya: export value of cut flowers 2019-2021 | Statista*. https://www.statista.com/statistics/1130772/monthly-export-value-of-cut-flowers-in-kenya/

Stonebraker, P. W., Goldhar, J., & Nassos, G. (2009). Weak links in the supply chain: Measuring fragility and sustainability. *Journal of Manufacturing Technology Management*, *20*(2), 161–177. https://doi.org/10.1108/17410380910929600

Taleb, N. N., Canetti, E., Kinda, T., Loukoianova, E., & Schmieder, C. (2012). *A New Heuristic Measure of Fragility and Tail Risks: Application to Stress Testing; by Nassim N. Taleb, Elie Canetti, Tidiane Kinda, Elena Loukoianova, and Christian Schmieder; IMF Working Paper 12/216; August 1, 2012*. https://www.imf.org/external/pubs/ft/wp/2012/wp12216.pdf

Teixeira, J. A. (2003). The Cut Flower: Postharvest Considerations. In *Journal of Biological Sciences* (Vol. 3, Issue 4, pp. 406–442). https://doi.org/10.3923/jbs.2003.406.442

Union Fleurs. (2020). *EU-wide survey provides a first estimate of the brutal impact of COVID-19 pandemic on the European Flower & Live Plants sector (March-April 2020) - Union Fleurs*. https://unionfleurs.org/news_events/eu-wide-survey-provides-a-first-estimate-of-the-brutal-impact-of-covid-19-pandemic-on-the-european-flower-live-plants-sector-march-april-2020/

Union Fleurs. (2021). *4.12 billion EUR of losses for flowers, plants sector across Europe*. https://www.floraldaily.com/article/9226524/4-12-billion-eur-of-losses-for-flowers-plants-sector-across-europe/

Union Fleurs, ENA, & AREFLH. (2020). *EU-wide survey provides a first estimate of the brutal impact of COVID-19 pandemic on the European flower & live plants sector in March and April 2020*. *June 16*. https://unionfleurs.org/wp-content/uploads/2020/06/PRESSRELEASE_EUsurveyFPC0VID19_20200616_ig.p

df

Wainwright, H., & Labuschagne, L. (2009). Crop protection and the kenyan flower industry. *Outlooks on Pest Management*, *20*(4), 153–157. https://doi.org/10.1564/20aug03

Wever, M., Wognum, N., Trienekens, J., & Omta, O. (2012a). Managing transaction risks in interdependent supply chains: An extended transaction cost economics perspective. *Journal on Chain and Network Science*, *12*(3), 243–260. https://doi.org/10.3920/JCNS2012.x214

Wever, M., Wognum, P. M., Trienekens, J. H., & Omta, S. W. F. (2012b). Supply chain-wide consequences of transaction risks and their contractual solutions: Towards an extended transaction cost economics framework. *Journal of Supply Chain Management*, *48*(1), 73–91. https://doi.org/10.1111/j.1745-493X.2011.03253.x

WITS. (2019). *Kenya Trade Statistics | WITS*. https://wits.worldbank.org/CountryProfile/en/KEN

World Bank. (2021). *CountryProfile | World Development Indicators*. https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=KEN

Worthington, I., & Britton, C. (2009). *Business environment*. Pearson's Education.

Xia, Y., Deng, X., Zhou, P., Shima, K., & Silva, J. A. T. da. (2006). The World Floriculture Industry: Dynamics of Production and Markets. *World Floriculture and Ornamental Markets*, *1*(35), 336–347.

Zeng, B., & Yen, B. P. C. (2017). Rethinking the role of partnerships in global supply chains: A risk-based perspective. *International Journal of Production Economics*, *185*(December 2016), 52–62. https://doi.org/10.1016/j.ijpe.2016.12.004

Zhang, W. (2021). The Case for Healthy U.S.-China Agricultural Trade Relations despite Deglobalization Pressures. *Applied Economic Perspectives and Policy*, *43*(1), 225–247. https://doi.org/10.1002/aepp.13115

11 Annex

Survey Questionnaire on Fragility of Kenya's cut flower sector and impacts as exposed by COVID-19-new

Dear Respondent, thank you for your willingness to participate in this survey. This study analyses The Impacts of COVID-19 lockdown policy on the cut flower sector in Kenya and analyses the fragility of the value chain. This is in fulfillment of the International Master of science in Rural development by Elizabeth Koech, a Masters student at Ghent University in Belgium. Your participation in this study is voluntary and your response shall remain confidential. Any queries can be directed to Elizabeth.Koech@Ugent.be

GENERAL INFORMATION

Name of organization *

Name of respondent *

Phone number *

Location of organizations' operations *

Please indicate your company or your business unit's function in the value chain (More than one option is available for vertically integrated operations) *

- [ ] Input supplier
- [ ] Flower farm
- [ ] Local merchant
- [ ] Exporting company
- [ ] International agent

What type of flowers do you produce?

e.g. roses, carnations

Which of the following categories of farm sizes would you classify your farm as?

- ( ) Local smallholder producer (less than 10 acres)
- ( ) Medium scale producer (10-30 acres)
- ( ) Large scale producer (Over 30 acres)

How many personnel do you employ?
What size of land do you have under flower production
Who owns majority shares in your organization?
What is the average volume of flowers you produce/ stems harvested per day?
THE FOLLOWING QUESTIONS ASSESS THE GENERAL CHAIN GOVERNANCE

What relationship do you have with your input supplier?

- One supplier supplies all inputs, agrochemicals, , green house , fertigation system and packaging material
- Two -four suppliers supply inputs, including agrochemicals, green house and fertigation system and packaging material
- Several suppliers, each supplying their own commodity,
- Several suppliers supplying one commodity

Who are your main buyers? *

- Contracts with supermarkets abroad
- Dutch auctions in the Netherlands
- Agents overseas
- Local merchants
- Others

If selected other in the above question, please explain

Which countries do you export to? *

- [ ] Netherlands
- [ ] UK
- [ ] UAE
- [ ] Other EU countries
- [ ] Others

If selected other, in the question above, please list the names

What is the level of dependency with your suppliers? *

Hint: How easy is it to replace supplier

- ◯ Not dependent
- ◯ Slightly dependent
- ◯ Somewhat dependent
- ◯ Very dependent
- ◯ Extremely dependent

What is the level of dependency with your buyers? *

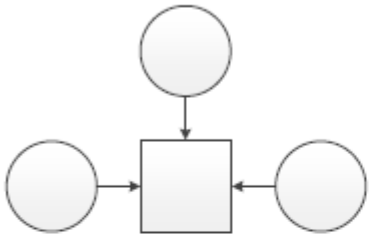
Hint: How easy is it to replace buyer

- ◯ Not dependent
- ◯ Slightly dependent
- ◯ Somewhat dependent
- ◯ Very dependent
- ◯ Extremely dependent

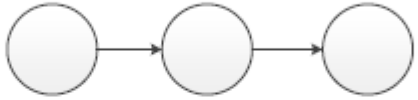
What kind of dependency do you have in the value chain? *

Show types of dependencies chart

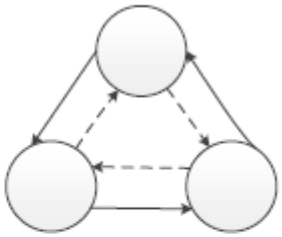
- ◯ Pooled interdependency
- ◯ Sequential interdependency
- ◯ Reciprocal interdependency
- ◯ Channel interdependency



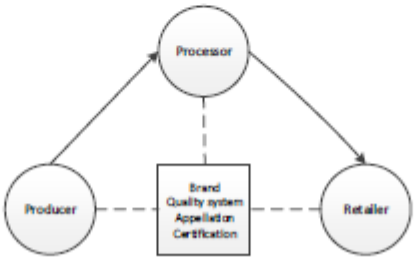
Pooled Interdependencies



Sequential Interdependencies



Reciprocal Interdependencies



Channel Interdependencies

THE FOLLOWING QUESTIONS SEEK TO QUANTIFY THE IMPACT OF THE LOCKDOWN

What percentage of workers were sent home due to the pandemic lockdown?

- No workers were sent home
- Less than 25%
- Between 25-50%
- Between 50-75%
- Above 75%

What percentage increase in price of inputs did you experience during the lockdown? *

- No change in input prices
- less than 10%
- Between 10-30%
- Between 30-50%
- Above 50%

Approximately how much percentage change in export value did you experience during the lockdown?

- No change in export value
- Decrease by less than 25%
- Decrease by 25-50%
- Decrease by 50-75%
- Over 75% decrease

Approximately how much percentage cancellation of orders did you experience during the lockdown? *

- ◯ No cancellation of orders
- ◯ Cancellation by less than 25%
- ◯ Cancellation by 25-50%
- ◯ Cancellation by 50-75%
- ◯ Over 75% orders cancelled

What mechanisms did your company employ to remain in business during the pandemic? *

- ☐ Business as usual
- ☐ Cut down on operations
- ☐ Sent workers home
- ☐ Doubled operations after restrictions were lifted
- ☐ Found new alternative markets to export to
- ☐ Others

If selected others in previous question, please explain

.....

How has the Kenyan Government intervened in recovery of the flower industry? *

- ☐ Tax relief ☐ Subsidies
- ☐ Specialized cargo flights ☐ VAT Refunds
- ☐ None ☐ Other

Please indicate the impact of a deterioration in the strength and alignment of the relationship with the supplier on business' continuity in the following scenarios

relationship with the supplier	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in the strength and alignment of the relationship with the buyer on business' continuity in the following scenarios

Buyer relationship	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in information and communication on business' continuity in the following scenarios

Information and communication	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in chain dependency on business' continuity in the following scenarios

Chain dependancy	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in state of the economy on business' continuity in the following scenarios

State of the economy	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in laws and regulations on business' continuity in the following scenarios

Laws and regulations	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in the Infastructure on business' continuity in the following scenarios

Infastructure	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in quality and performance on business' continuity in the following scenarios

Quality and performance	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in human resources on business' continuity in the following scenarios

Human resources	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of a deterioration in cashflow on business' continuity in the following scenarios

Cashflow	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%										

Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of socioeconomic stability on business' continuity in the following scenarios

Socioeconomic stability	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%										

Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Please indicate the impact of operational reliability on your business' continuity in the following scenarios

Operational reliability	0 to -10% impact	-10% to -20% impact	-20% to -30% impact	-30% to -40% impact	-40% to -50% impact	-50% to -60% impact	-60% to -70% impact	-70% to -80% impact	-80% to -90% impact	-90% to -100% impact
Deterioration by 10%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 20%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 30%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 40%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 50%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 60%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 70%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 80%										

Deterioration by 90%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Deterioration by 100%	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

How long did it take your organization to go back to full operations *

- ◯ 1-3 months
- ◯ One month or less
- ◯ 3-6 months
- ◯ We are not at full capacity to date

Thank you for participating in this survey. The results of this research will be made available to you upon request via email by 30th October 2021.