Designing Supply Chain to Hedge Against Disruptions: A Review of Literature in General and Agro Food Supply Chains

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Abstract

Recent events unveiled that it has become eminent to understand the wide dimensions of the supply chains disturbance and how to mitigate its effect on the performance. The complexity of globally stretched supply chains of different products and specifically agricultural food supply chains have increased the sensitivity of the performance if any disturbances occur. This paper reviews the literature from 2017 concerned with resilience in supply chains and agro food supply chains, with the aim of building a complete understanding of the methods and strategies to deal with disruptions. The review classifies the risks, decision variables, and objectives (with a deeper look on resilience and sustainability measures) considered for both general and agro food supply chains to reach a conclusion on the most appropriate strategies. The different model types are addressed together with the appropriate solution techniques to reach an optimum performance for the model. We identified the research gaps and highlighted the different research paths that are scarce in literature. The results show the dearth in research on agro food supply chains and application of the models on real case studies. Sustainability is rarely addressed and linked with resilience. Limited research addressed resilience as a performance measure although it is of great importance, while a few considered the tradeoff between financial and resilience measures.

Keywords
Supply Chain Management, Resilience, Agro Food Supply Chain, Sustainability, Review

1. Introduction
Nowadays, the novel supply chains in our emerging global economy are interconnected and complex. This is mostly due to the articulation of research about the benefits of adapting strategies like global outsourcing, manufacturing in global destinations, supply base rationalization, just-in-time deliveries, and many more. Companies could not look over the advantages of these strategies but applying them shed the light to new complications that the chains are now

facing owing to the vulnerability of the chain to exchange rates, disruptions due to strikes, natural disasters and new applied taxes, and any political and economic instability. Moreover, the recent disruptions due to the global spread of Covid19 drastically affected the world causing a halt to the chains across different echelons due to a number of problems like logistics for supplies and finished products delivery, closure of retails and scarcity of products, in other words some industries became paralyzed. The threshold of the effect of Covid 19 can be clearly noticed across the globe, revealing the urgent need for developing a proactive supply chain design “SCD” to take control of the chain when sudden disruptions of that magnitude occur. Resilience policies are now being the forethought of supply chain study and applications, resilience signifies strength and flexibility of the chain. There are numerous definitions of supply chain resilience, (Scholastica N. Emenike, 2020) defines it as the capacity of a supply chain network to overcome stress or system failure and mitigate the impact of disruptions as much as possible. Supply chain resilience “SCR” arose from the general topic of risk management, resilience plans for greater disruptions that are less likely to occur but threatens the supply chain continuousness itself. In this now globalized supply chains crossing borders all over the world, designing without considering such a disruption that affects the chain in countless number of ways should not be ignored. Research by (Armin Jabbarzadeh, 2018) , (Dolgui, 2020), (Ali Tolooie, 2020) and (Fatemeh Sabouhi, 2020) sheds light on how the effective supply chain design leads to higher performance, (Jafar Namdar, 2017), (You, 2019) and (Aguila, 2019) pointed out how costs where reduced during disruptions. (ElMaraghy, 2020) Called for more studies concentrating on the first tier of the supply chain which is the supplier.

Resilience in the Agro Food Supply chain “ASC” has been gaining more importance recently with the increasing volatility of the chains across the globe, firms are trying to cope with the pressures of not only a growing population but one with shifting consumer preferences in which they demand freshness and quality. The majority of developing countries rely heavily on agriculture, since these chains are now vulnerable. The Agriculture Organization FAO 2020 stated that COVID-19 is affecting these chains severely at both ends (Rohit Sharma, 2020). Disruptions due to epidemic events is scarce in the existing literature of ASC (Seyed Mohammad Gholami-Zanjani, 2021) and (Guoqing Zhao, 2020), to this end there are calls for an advanced stochastic multi-period models to design a resilient ASC (Esteso, et al., 2018) (Rahimifard, 2018), to model and quantify risk mitigating strategies (Haitao Li, 2020). Finding quantitative measures for the resilience is scarce in literature as mentioned by (Dmitry Ivanov, 2017), (Armin Jabbarzadeh, 2018), (Igor Linkov, 2020) and specifically in ASC (Seyed Mohammad Gholami-Zanjani, 2021).

1.1 Objectives

To effectively bridge the gap that was mentioned by (Dmitry Ivanov, 2017), (Seyedmohsen Hosseinia, 2019), and (Adbor, 2020) between practical and research needs, one must first study closely the different SCD strategies. The broad objective of this paper is to review the developed studies for designing resilient supply chains to hedge against disruptions while concentrating on ASC. The review will cover the risks, strategies, decision variables, objectives, and sustainability, modelling and solution techniques. The contributions of this work are threefold, identifying the different risks, strategies and decision variables for designing a resilient supply chain, providing guidance on which modelling and solution technique is best used with resilience measures and finally presenting the different ways to quantify resilience and its relation with sustainability.

2. Literature Review

2.1 Resilience in SCM

(Adbor, 2020) defined resilience to be “about systems changing as circumstances change, adaptation when necessary, and transformation rather than continuing to do the same thing better”. There are two types of supply chain risks, operational risks related to ordinary disturbances like the uncertainties in lead time, demand and supply, and disruptive risks which are less frequent risks but their effect has a much greater amplitude on the chain, like natural disasters and Epidemic outbreaks that have a long duration and ripple effects across the chain (Jamal El Baz, 2020). Establishing resilience in the chain is connected to the design of the chain, to be able to withstand disruption a chain should have been already designed for it, all strategies for resilience are in one way or another related to the SCD. For example (You, 2019) considered achieving a resilient supply chain on two steps, the first is finding the best supply chain network design, planning for extra capacity to increase resilience, and the second is to increase redundancy by having extra facilities or adding extra production capacity.

2.2 Resilience in ASC

The food supply chain is considered one of the infrastructures of a country as it delivers essentials to customers not only profit for companies (Seyed Mohammad Gholami-Zanjani, 2020), its resilience is concerned with the unbroken flow of safe food from farm to fork. The supply chain is affected by a lot of external and internal factors, for the ASC main risks that cause the greatest disruptions (affecting supply, demand and logistics) are either weather or politics related (Guoqing Zhao, 2020). (Bottani, 2019) Grouped the food supply chain into three phases, the supply whether they are farms, chemicals and or packaging materials, processing includes all the processing plants and transformation activities and distribution like wholesale centers, retailers, markets and delivery activities. The ASC intricacy is owed to their unique vulnerabilities, the product's limited shelf-life, the safety of the product requires extra measures in transport and storage and the variability in quality, all this adds to the importance of resilience in agro food chains.

3. Review Methodology

The methodology followed for the literature review is the systematic review procedure described by (David Tranfield, 2003) to identify significant contributions to a research field, analyzing literature to find answers to research questions. The first step is deciding on the focus of study and the scope, which is resilience in supply chain management in general and specifically in agro food products. The following keywords were used in searching, supply chain management, resilience, sustainability, agro food supply chain resilience, agro food supply chain resilience, disruptions. Concisely, our main research questions are: Which SCM issues and strategies are addressed when designing for resilience? What sources of uncertainty are considered? Which decision variables are critical? Which sustainability aspects are tackled? How are uncertain parameters modeled and how are they solved? How to measure resilience of a supply chain? In order to find the relevant research papers, the papers were retrieved from databases of Web of Science library and Google Scholar. The retrieved papers dated from 2017 were later refined. Analysis of data by breaking down separate studies, identifying key points and analyzing relationships between different parameters, to conclude with identifying of gaps.

4. Results and Discussion

4.1 Resilience in Supply Chain Management

There are numerous strategies to aid in making the supply chain more resilient: increasing capacity at manufacturing or creating a capacity buffer, multiple sourcing and contracting with backup suppliers and ports (Armin Jabbarzadeh, 2018). These strategies can be divided into proactive and reactive strategies, the former are preventive actions that should be taken before a disruption occurs even if it never happens, representing the flexibility and readiness of the chain that helps in the visibility and collaboration, it compromises of fortification (reinforcing and protecting some facilities against possible disruption), multiple facility or supplier, technological investments, inventory safety stock and having several transport routes. The latter are the strategies that will be implemented once a disruption occurs, representing the responsiveness of the chain, it compromises of backup facility, supplier and transport routes, capacity buffer or expansion and alternative scenarios (Kannan Govindan, 2017).

Table 1 presents risks, strategies, and echelons in reviewed supply chain papers When disruption affects the production, the strategy is to use the capacity buffer or expansion (Jamal El Baz, 2020) , they are both used to cover the uncertainty in demand as well (Vahid Nooraie, 2019) and (Fattahi, 2020). It is eminent from the table that when complete disruptions is considered, alternative scenarios are frequently considered like in (Fatemeh Sabouhi, 2020) and (Sube Singh, 2020), this is due to the fact that numerous strategies should be executed subsequently which leads to high costs, thus it is better to reach the least cost strategy while maintain performance. Looking closely in Figure 1 the majority of research considers both reactive or combined strategies, this is due to the high cost of implementing the proactive strategies, and thus most firms would prefer to pay this cost only when disruption occurs. Figure 2 shows the proactive strategies, the safety stock strategy is widely used since it is one of the oldest strategies and can be easily modified by time, technological investment in information sharing comes next because with all the new technologies available at different costs it is common to assess its effectiveness. In figure 3 for the reactive strategies, alternative scenarios is by far the most frequent strategy addressed since it compares between different options and gives the most cost effective one.

Table 1. Risks, strategies, and echelons in reviewed supply chain papers

Reference	Type of Risk		Strategy		Echelons
	Complete	Partial	Proactive	Reactive	
(G. Guilléna, 2005)		D		BS ,Cp & A	S-P-DC
(Ivanov, 2017)	x		F & I		All
(Jafar Namdar, 2017)		S	Tech, MS	BS&A	S-P
(Armin Jabbarzadeh, 2018)		P&S		Cp &BS	All
(Ivanov, 2018)		DC		BS, Cd, A	S-DC-C
(Fei Ye, 2018)		D	I	A	All
(Sabouhi, 2018)	x		MS,I&F	A	All
(Armin Jabbarzadeh, 2018)	x		MF	A	All
(Aguila, 2019)	x		MF		All
(Vahid Nooraie, 2019)		S-D	Tech	Cp	All
(You, 2019)		P&D		Cp, A	All
(Hosseini & Ivanov, 2019)		S	MS		All
(Hosseini, 2019)		S	MS	BS, Cs, A	All
(Diabat, 2019)		DC & T	MF	BT	All
(Yuji Sato, 2020)		D & T		A	S-P
(Fatemeh Sabouhi, 2020)	x		MS&MT	Cp &Cd, A	All
(Jamal El Baz, 2020)	x		Tech	Cp &Cd	All
(Glonar Bahzadi, 2020)		T		BT,A	All
(Sube Singh, 2020)	x			BF & A	D-C
(Dolgui, 2020)	x		Tech & I	A	All
(Ivanov, 2020)	x		I	Cp, A	All
(Fattahi, 2020)		D&C	I	Cd, A	DC-C
(Ali Tolooie, 2020)		P	F	A	S-DC-C
(Ivanov, 2020)	x			BS, Cp, Cd	All
(Ivanov, 2020)	x		I	BF, Cd , Cp, A	All
(ElMaraghy, 2021)	x		I	Cp	All
(Masoud Alinezhad, 2021)		S	MS	Cp, Cd	All

*S : Supplier, P: Producer, D:Demand, T: Transportation, DC: Distribution center, C: Customer
*F: Fortification, MS: Multiple Supplier, MF: Multiple Facility, Tech: Technological investment, I: Inventory safety stock, MT: multiple transport routes, BS: Backup Supplier, BT: Backup Transport, Cp: capacity buffer at P, Cd: Capacity at D, A: Alternative scenarios, BF: Backup facility

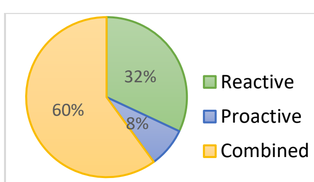

Figure 1. Percentage of Supply chain papers considering each strategy

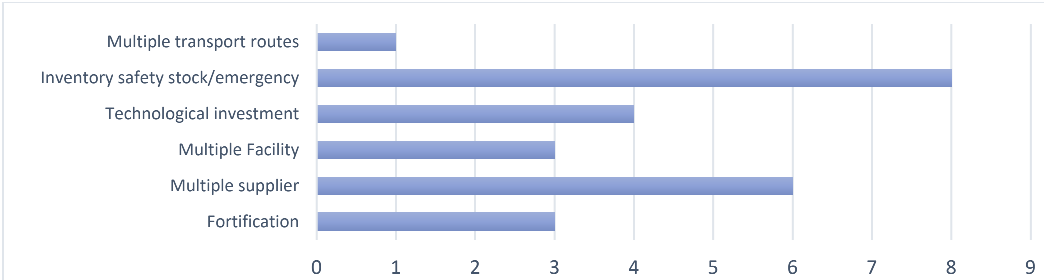

Figure 2. Frequency of proactive strategies

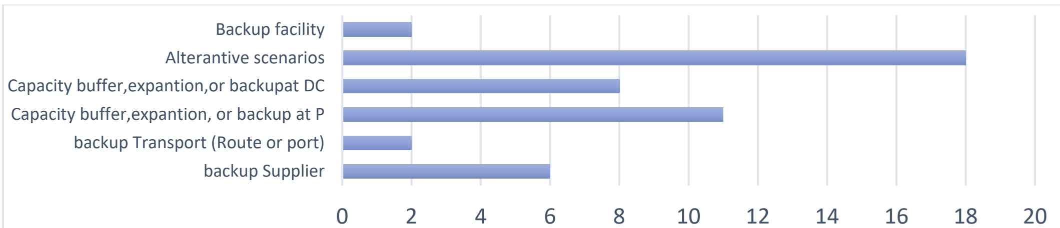

Figure 3. Frequency of reactive strategies

The majority of the decision variables addressed were related to design parameters of the supply chain. Around 43% of the papers considered multi-stage models owing to the ripple effect of disruption, in which the decision variables are sometimes divided into variables to primary consider and others depending on the first stage ones or variables decided according to the disruption phase whether it is pre disruption or during disruption variables. Facility location was the addressed in (You, 2019) and (Fatemeh Sabouhi, 2020) as a first stage decision variable for the model combined with the capacity of each manufacturing facility. However, the second stage variable is different in each model, (Fatemeh Sabouhi, 2020) Concentrating on deciding the appropriate suppliers, the transportation route and the flow of materials between each chain node, whereas the model of (You, 2019) concentrated on the schedule, procurement and transportation of products. The quantity of manufacturing goods was addressed as the only decision variable by (Fei Ye, 2018), however (Vahid Nooraie, 2019) coupled it with the quantity per supplier, (Armin Jabbarzadeh, 2018) considered it to be the decisions to implement during disruption. In general as seen in figure 4, Transportation variables are least studied and the procurement is the most common. The multi-staged models in figure 5 shows that capacity, location and supplier decisions are only considered in the first stage, whereas procurement is considered in both stages of the model.

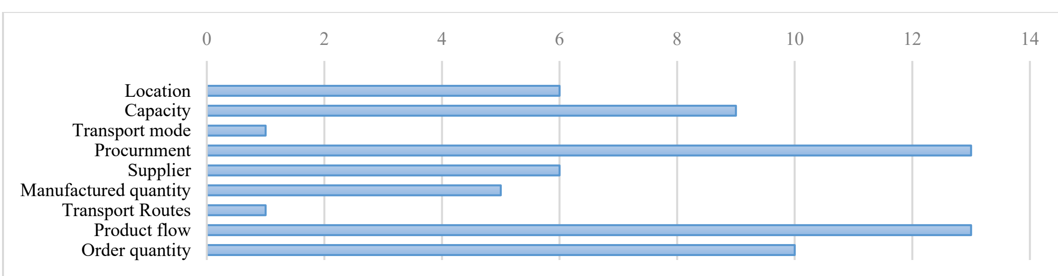

Figure 4. Frequency of each decision variable in Supply chain papers

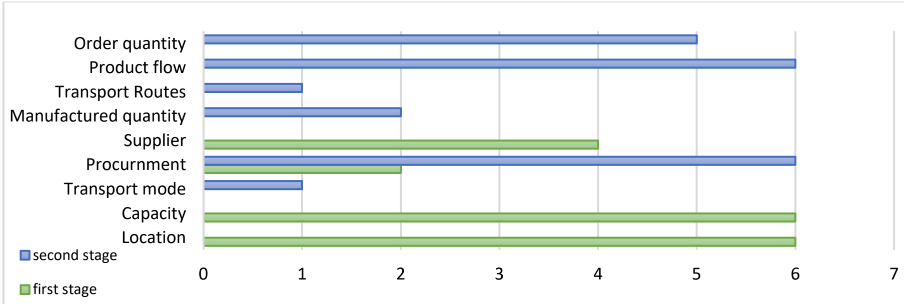

Figure 5. Frequency of each decision variable in multi staged models

The objective of any model is naturally to maximize the performance. Objectives can be categorized as shown in table 2 according to their purpose into financial, sustainability and customer oriented objectives. Resilience as a performance was measured using different methods, in which it was either measured by integration of the impact of disruption on the plant's functions from the start of disruption to the time when recovery is complete (Scholastica N. Emenike, 2020), or as the ratio between the integration of supply chain performance in normal circumstances and during disruption (You, 2019). Also (Hosseini & Ivanov, 2019) Measured resilience as the ratio of the recoverability and vulnerability values. In (Seyedmohsen Hosseinia, 2019), they measured the loss of resilience by summing up lost capacity and the cost of recovery suppliers, while in (Glonar Bahzadi, 2020) they measured the time to recovery and lost profit during disruption.

Table 2. Objective of each reviewed paper

Reference	Objective			
	Financial	Customer	Sustainability	Resilience
(G. Guilléna, 2005)	P	LS		
(Ivanov, 2017)		SL & LT	Sus: s	
(Jafar Namdar, 2017)	C			
(Kannan Govindan, 2017)	P	LT		
(Glonar Bahzadi, 2020)	P	LS		
(Fei Ye, 2018)	P			
(Armin Jabbarzadeh, 2018)	C		Sus: E & s	
(Sabouhi, 2018)	C			
(Armin Jabbarzadeh, 2018)	C	LS		
(Diabat, 2019)	C	LT		
(Vahid Nooraie, 2019)	C	Rs		
(You, 2019)	C			R
(Hosseini & Ivanov, 2019)				R
(Hosseini, 2019)	C			
(Aguila, 2019)	C			R
(Sube Singh, 2020)	C	LT & SL		
(Ivanov, 2020)	C			
(Fattahi, 2020)	C			
(Ali Tolooie, 2020)	C			
(Ivanov, 2020)	Rv, P	SL & LT		
(Fatemeh Sabouhi, 2020)	C	SL		

Reference	Objective			
	Financial	Customer	Sustainability	Resilience
(ElMaraghy, 2021)	C, P	SL & LS		
(Masoud Alinezhad, 2021)	P & C	Rs	Sus:E	
*P: Profit, C:Costs, LS: Lost Sales, SL: Service level, Rs: Responsivness, LT: Lead Time, Sus: Sustainability, E: Environmental, s: Social, R: Resilience				

Resilience is a lot of times connected to supply chain sustainability, due to the influence the chain has on the economic topics like employment rates and natural resource consumption. (G.Calleja et al, 2017) and (Chong, 2020), called for studying sustainability and resilience together, the review shows that it is measured in only 7% of the reviewed papers. Sustainability is the interactions between the echelons of the chain that aids environmental and/or social topics to the chain (Armin Jabbarzadeh, 2018). The environmental sustainability is concerned with how to properly use the resources with minimum impact on the environment, whereas social sustainability is considering the consumers and the employees while planning (Scholastica N. Emenike, 2020). In order to achieve increase the resilience of the supply chain to mitigate the ripple effect of disruption while considering sustainability (Dmitry Ivanov, 2017) used different scenarios of single sourcing, facility fortification and inventory placement to find the influences on the service levels, lead time and inventory policies. The results concluded that sustainable single sourcing enhances the ripple effect when comparing it dual sourcing.

4.2 Resilience in Agro Food Supply Chain

A number of strategies were not studied in the agro-food chains research papers (as seen in table 3), such as having multiple facilities or a backup facility. That is probably due to the fact that the critical parts of the agro-food chains are the supply or demand while the processing facility is rarely affected by disruption and also it needs to be close to the farms so the location cannot be easily changed. The proactive strategy is mostly studied as seen in figure 6, (Haitao Li, 2020) optimized inventory safety stock for a multi-echelon grapes supply chain in India where demand is uncertain and service level is maintained. Multiple supplier strategy and technology applications for information sharing where the most researched strategies (Seyed Mohammad Gholami-Zanjani, 2021) researched how investing in applying technological infrastructure of different levels to increase the collaboration across the chain and maintain the profit when disruptions occur at the producer or the distribution center. Whereas 33% of the reviewed research implemented the reactive strategy and mostly a backup supplier is considered which is because suppliers for agro food are vastly affected by disruptions. (Behzadi, 2017) proved that having a dynamic transshipment model to be able to achieve flexible rerouting and intermediate locations of distribution centers can hedge against disruptions in the demand and provide profit under market changes.

Table 3. Risks, strategies, and echelons in reviewed ASC papers

Reference	Type of Risk		Strategy		Echelons
	Complete	Partial	Proactive	Reactive	
(Bottani, 2019)		S-D	MS		All
(Haitao Li, 2020)		D	I		All
(G. Behzadi, 2017)		D		BT	All
(Seyed Mohammad Gholami-Zanjani, 2021)		D-P	Tech & MS	BS&Cp	P-D-C
(Seyed Mohammad Gholami-Zanjani, 2020)	x			BS,Cp,Cd & A	P-D
(Anil Kumar Ravulakollu, 2018)	x		Tech		S-D
*S : Supplier, P: Producer, D:Demand, T: Transportation, DC: Distribution center, C: Customer *MS: Multiple Supplier, Tech: Technological investment, I: Inventory safety stock, BS: Backup Supplier, BT: Backup Transport, Cp: capacity buffer at P, Cd: Capacity at D, A: Alternative scenarios					

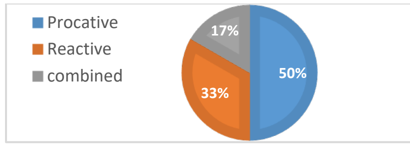

Figure 6. Percentage of ASC papers considering each strategy

Research on agro-food supply chains concentrated mostly on the strategic decision variables, when other variables are addressed there is always a strategic variable is present with them except for (Haitao Li, 2020) in which the decision variable was the transportation mode selected and the lead time was set as a decision variable rather than a performance measure or an objective for that matter. The location of the facilities is widely discussed (figure 7) because of the product's nature, it is critical to have a facility close to the farm while at the same time close to the market or a transportation hub to deliver the products with minimum lead time. Procurement and product flow are mostly researched, that is also due to the geographical distribution together with the vast volume of trade. Half of the researched papers considered multi staged models, the chart in Figure 7 shows the frequency of decision variables addressed, and strategic variables are considered in the first stage and the operational in the second, whereas the tactical is considered in both stages owing to the time frame of each decision variable. A number of papers consider multiple variables from each category, (Seyed Mohammad Gholami-Zanjani, 2021) suggested scenario-based location-inventory model subjected to disruptions in demand and capacity at their facilities, the first stage decision variables were for quantity of products produced, allocation and the capacity at distribution facility, while the second stage variables included the inventory level and safety stock is considered. Research sometimes considers variables from all categories at once in a single stage model, as the case of (Bottani, 2019) where a resilient tomato supply chain is studied, decision variables considered were the capacity of processing facilities, supplier selection and allocation.

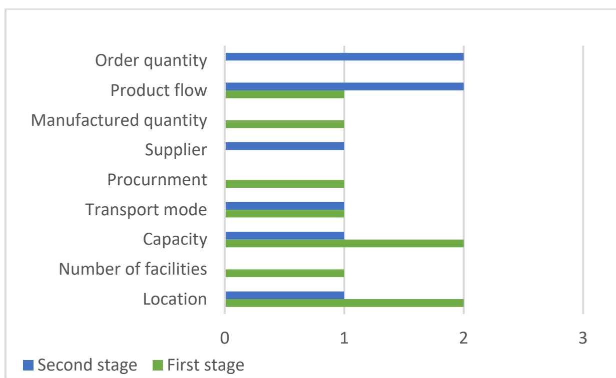

Figure 7. Frequency of each decision variable in ASC papers

The performance of a supply chain is the objective of any firm, a financial objective is logically always the first objective usually combined by another objective according to the preference of the organization. Most of the research puts in consideration customer oriented objectives, and only one paper measured resilience as an objective in an indirect way. The objective of the model was to maximize profit while minimizing risk, for a multi-period model that analyses market demand disruption effects in a kiwi supply chains (Behzadi, 2017). Risk was risk measured by minimizing perishability (the risk of delivering products that are not fresh or reducing waste) this was minimized by introducing intermediary nodes that produces a transshipment model to supports flexible rerouting.

When it comes to agro food chains, sustainability is essential owing to challenges from the growing population affecting the demand for food, yield problems due to climate change and environmental degradation that leads to resource constraints, food waste (*Nearly half of all fruit & vegetables produced globally are wasted each year* (Andersen, 2022)), up to the limited wages of employees in farms which affects harvesting with all its social aspects (Mogale, 2019). One of the examples is reducing carbon dioxide emissions together with costs by developing a bi-objective decision support model for sustainable food grain chains in India (Mogale, 2019). However research in this area is scarce since out of the reviewed agro-food supply chain papers only 15% considered sustainability, this shows that there is a prominent research avenue in this area.

4.3 Modelling and Solution Techniques

There are a number of methods to undergo research, they can be either qualitative or quantitative. When reviewing literature it became clear that the highest percentage of methods are the applied (31%), followed by the same percentage for developing an understanding of the framework which is a conceptual technique, owing to the fact that validation and application needs a lot of data and experimentation. Whereas the analytical models are only 21% and the empirical 14%.

Optimization is a solution technique that can be done mathematically or with the help of a software to solve a model that can withstand against disruptions with the help of technological innovations with the minimum cost (Scholastica N. Emenike, 2020). Developing a mathematical model can sometimes be stochastic (Armin Jabbarzadeh, 2018) and (Glonar Bahzadi, 2020) or deterministic (Mogale, 2019). Stochastic programming models are scenario-based, their parameters are characterized by discrete scenarios each having a different probability (Alexandre Dolgui, 2017). For most stochastic programming models like (Fei Ye, 2018) and (Fatemeh Sabouhi, 2020) demand is usually an uncertain parameter while in a robust stochastic programming model (Ali Tolooie, 2020), facility disruptions are also uncertain.

Both two stage stochastic programing and the mixed integer programming has been extensively applied (39%). (Glonar Bahzadi, 2020) Applied the latter for perishables supply chain to hedge against port disruptions, to maximize both profit and recovery level while minimizing time to recovery. An example of using a mixed integer programming model is that of (Seyed Mohammad Gholami-Zanjani, 2021), where a location-inventory two-stage model on a discrete multi-period time horizon model was to protect the chain from disruptions at producer or distribution center. (Fattahi, 2020) First developed a two-stage stochastic mixed integer non-linear programming model which was later reformulated as a conic quadratic mixed-integer program (9% of the papers) to protect against facility disruptions by investigating the effects of having a capacity buffer and alternative inventory configurations on the costs. (Vahid Nooraie, 2019) used multi-objective integer programming modelling to study the effect of increasing responsiveness on reducing the total costs and increasing the resilience using capacity buffers and investing in technology, whereas (Aguila, 2019) formulated a single period integer programming model to minimizes the risk score and costs when overall disruptions occur with the help of the proactive strategy.

The majority of the developed models were optimized either mathematically like using a generic algorithm (Vahid Nooraie, 2019) or mostly (71%) with the help of a software to be able to get an exact answer. Stochastic programming models can be solved using different algorithms like (Fatemeh Sabouhi, 2020), in order to find out the optimum strategy optimization is solved by extension of Benders decomposition algorithm called multi-cut L-shaped method, CPLEX is the most commonly used around 41% of the times as seen in pie chart of figure 8. Simulation methods have proved to be an appropriate tool for the study of SCD as mentioned by (Mary J. Meixell, 2005) and (Dmitry Ivanov, 2017), it helps mimic the performance of the chain. (Ivanov, 2017) used discrete event simulation on Logistix to introduced different scenarios using simulation to identify the best sourcing and inventory policy to increase supply chain resilience and decrease the ripple effect when there is a disruptions along different parts of the chain, later in (Ivanov, 2018) Simulated a supply chain using a numerical example of products for four regional markets to mimic the effect of disruption of a distribution center in the recovery and post-disruption periods using CPLEX, (Sube Singh, 2020) used CPLEX to simulated the impact of Covid 19 on the transportation and distribution of grains in India.

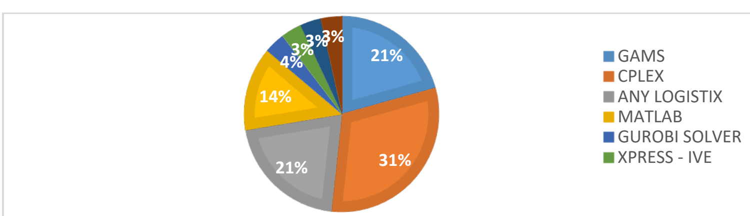

Figure 8. Using each software percentage

4.4 Gap Analysis

Noticeable gaps have been recognized from works of studied literature that point to important future research ideas. A significant gap exists for applying models in different industries like agricultural and energy and adaptation of ASC research on a specific food type. More research is needed that develop case studies with real company data on applying resilience frameworks to validate the suggested research work. The following problems should be addressed:

- Risks: Consider post disruption period when designing and the revival policies.
- Strategies: Design strategies and models around the disruption phases and the time lags between them.
- Decision variables: Models should take into considerations transportation modes and routes decisions as variables since they can drastically reduce risks and increase resilience. ASC research should study the number of facilities as a variable to increase resilience.
- Objectives: Develop appropriate measures to quantify resilience and sustainability as an objective.
- Sustainability: Study the three levels of sustainability with resilience to quantify their impact. To the researcher's knowledge, there is currently limited work on agro-food extended to the full chain from farm to customer that has sustainability and resilience as objectives.
- Modeling techniques: Extend the models to be multi-period, multi objective models by using multi stage modelling under uncertainty. There should be more studies on the impact of digitalization, big data analytics on resilience: How to make use of available digital technology like simulation and digital twins improve resilience.

5. Conclusion

This study presents a review of supply chain resilience to mitigate the effect of disruption in general and agro-food supply chains and to contribute to the call of several scholars (Ana Estesoa, 2018), (Bottani, 2019), (Hosseini, 2019) and (Adbor, 2020). Although the emphasis is on getting a deeper understanding of the concept of resilience, its strategies and important aspects, this work also concentrates on how researchers introduced a resilient supply chain design, how their work was formulated and implemented, what decision variables were considered, how the work was solved to find the optimum configuration and in some cases applied on a specific chain. SCR is a disruption driven notion that requires precise configurations, thus findings reveal that numerous strategies are efficient in the face of disruptions, like scenarios to choose between the strategies and combining proactive and reactive strategy is recommended. The reactive strategy that has the most positive influence on the chain is having a capacity buffer, whereas the proactive strategy is investing in technology to provide visibility. The review proved that the decision variable is always linked to the strategy, supplier and capacity decisions are critical for designing a resilient supply chain, whereas decisions concerning the product flow have been widely addressed for ASC and showed great improvements in performance. The objective function is oriented towards the financial objective of cost minimization, and to a smaller extent, maximization of service level which is interrelated to the resilience. Critical objectives for ASC are of waste, controlling this objective reduces costs and increases resilience in most cases. Furthermore, having the objective of minimizing lead time has positive influence on the ASC resilience, the successful model for these type of chains mostly has a dual objective of financial and customer orientation. The highly successful models are the ones who dealt with the fact that disruption effect is gradual, consequently variables studied should be formulated into a two stage linear programming model that will later be optimized with the help of a software. Finally, the findings provide that a stochastic model is most commonly formulated and solution is reached by solving it on CPLEX solver in the GAMS software.

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