

Blurred lines: the timeline of supply chain resilience strategies in the grocery industry in the time of Covid-19

Maria Concetta Carissimi (corresponding author)

Logistics and Supply Chain Research Center, LIUC University, Castellanza, Italy
E-mail: mcarissimi@liuc.it

Lorenzo Bruno Prataviera

Cranfield School of Management, Cranfield University, Bedford, UK
Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Milan, Italy

Alessandro Creazza

Logistics and Supply Chain Research Center, LIUC University, Castellanza, Italy

Marco Melacini

Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Milan, Italy

Fabrizio Dallari

Logistics and Supply Chain Research Center, LIUC University, Castellanza, Italy

Abstract

To anticipate, adapt and respond to, and recover from disruptions, firms need to enhance supply chain (SC) resilience. The spread of the COVID-19 pandemic in 2020 represented a unique opportunity to investigate it empirically. This study focuses on the exploration of the resilience strategies adopted to deepen their temporal characteristics and contribute to developing the current understanding of proactivity and reactivity, something that needs to be further investigated. Multiple-case study research was conducted considering 21 Italian companies in the grocery industry. Results show that with the outbreak of the pandemic, companies adopted a set of 21 strategies that spanned five resilience categories: redundancy, flexibility, agility, collaboration, and innovation. To explain the temporal characteristics of the identified resilience strategies we propose an original taxonomy that elaborates the previous theory by introducing two new dimensions related to the strategies' timing ("when?" and "how long?"). Each dimension can be complemented with other sub-dimensions that explain the design and activation of resilience strategies, and their utilisation and availability. The proposed taxonomy broadens the narrow view offered by existing research on the temporal dimension of resilience, as multiple layers are needed to disentangle the temporal characteristics of different strategies. It also provides an original viewpoint on interpreting the strategies' proactivity or reactivity as their boundary is increasingly blurred. Lastly, the study opens up to future investigations of the antecedents of the design and utilisation/activation of resilience strategies, as companies could rethink their managerial decisions based on the continuous evolution of their operating environment.

Keywords supply chain resilience; Covid-19; case study research; grocery supply chains; disruption; strategy

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All the authors declare that they have no conflicts of interest.

Availability of data and material

No numerical data is linked to this work.

Code availability

Not applicable

Ethics approval

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to participate

Informed consent was obtained from all individual participants included in this study.

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Multiple-case study research was conducted considering 21 Italian companies in the grocery industry. Results show that with the outbreak of the pandemic, companies adopted a set of 21 strategies that spanned five resilience categories: redundancy, flexibility, agility, collaboration, and innovation. To explain the temporal characteristics of the identified resilience strategies we propose an original taxonomy that elaborates the previous theory by introducing two new dimensions related to the strategies' timing ("when?" and "how long?"). Each dimension can be complemented with other sub-dimensions that explain the design and activation of resilience strategies, and their utilisation and availability.

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1 Introduction

Today's business environments are increasingly dynamic and turbulent, and supply chains (SCs) face numerous events that threaten to disrupt operational activities, jeopardise performance (Hosseini et al. 2019) and affect critical infrastructures (Dynes 2008). In 2020, the COVID-19 pandemic swept across the globe in a matter of months, abruptly reminding companies of how vulnerable their SCs are (Ivanov and Dolgui 2021). The pandemic effects provoked considerable impacts on both demand and supply within SCs, including a tremendous ripple effect that deeply affected the grocery industry worldwide (Chowdhury et al. 2020; Sharma et al. 2021). The huge uncertainties in supply and demand highlighted the importance for companies to adequately handle risks and increase SC robustness, flexibility, and agility or, in other words, SC resilience (Hobbs 2020; van Hoek 2020a). SC resilience generally implies that a system can adapt in order to regain a new stable position after perturbations (Colicchia and Strozzi 2012; Hohenstein et al. 2015). Therefore, it is deemed to be highly important for companies to anticipate, adapt and respond to, and recover promptly from unpredictable events (Ponomarev and Holcomb 2009; Wieland and Wallenburg 2013, 2012).

Nevertheless, most of the SC resilience-related research is of a theoretical nature (Ho et al. 2015; Belhadi et al. 2021), and scholars have increasingly been recommended to carry out first-hand empirical research (Sreedevi and Saranga 2017; Tang 2006a; Wieland and Wallenburg 2012). The COVID-19 pandemic provided a rich opportunity to conduct such empirical research on SC resilience (Ivanov and Dolgui 2021; Ivanov and Dolgui 2020b; Queiroz et al. 2020), as well as on related initiatives that have been called for several times in the last two decades (van Hoek 2020a; Norrman and Wieland 2020).

According to whether they are introduced before, during, or after a disruption (Hosseini et al. 2019), resilience strategies are typically classified as either proactive or reactive (Durach et al. 2015). This also relates to the main phases of SC resilience, namely readiness, response, recovery, and maintenance (Hohenstein et al. 2015). However, the boundary between proactivity and reactivity seems increasingly blurred, and firms are adopting more nuanced approaches (Roscoe et al. 2020). The distinction between proactive and reactive strategies appears to be guided by the moment when a strategy is introduced (Kilubi 2016), but the same strategy could be considered either proactive or reactive by different companies (Stone and Rahimifard 2018). Moreover, the relationship between the type of approach (proactive or reactive) and the temporal dimension of SC resilience strategies is sometimes ambiguous and scarcely explored, and further research has been recommended to scrutinise it (Hosseini et al. 2019). Resilience strategies are not univocally related to an individual risk event, and the raging pandemic highlighted the need to improve the current understanding of the short- and long-term implications of any

disruption (Belhadi et al. 2021). Therefore, this study aims at deepening the timeline of different strategies to enhance the resilience of future SCs, as this could enable organisations to establish more suitable preparation and response plans (Kochan and Novicki 2019). Two research questions (RQs) were thus formulated:

RQ1: What strategies were introduced to improve SC resilience with the onset of the Covid-19 pandemic?

RQ2: How do companies approach SC resilience with respect to its temporal dimension, and how does this relate to proactivity or reactivity?

As few contributions have considered this temporal perspective to investigate SC resilience, we conducted qualitative case research, since it allows for collecting thick data that creates opportunities for deeper theorizing (Flyvbjerg 2006); multiple-case research design was shaped to increase external validity and to reduce the risk of misjudging single events (Barratt et al. 2011; Yin 2014). To limit the research scope and to simultaneously address the urgency to quickly provide answers to contingent issues (van Hoek 2020a), the problem is considered within a given empirical domain, thus resulting in a mid-range theory approach (Stank et al. 2017). Specifically, we considered 21 companies active in the Italian grocery SC, including 15 manufacturers and 6 retailers. COVID-19 effects were suffered by almost every business (Napoleone and Pratavia 2020) but grocery SCs were unanimously considered to be vital to every country (Barcaccia et al. 2020, Sharma et al. 2021). Along with food supply chains, they were seen as one of the most critical infrastructures (Muhlhauser, 2021), being allowed to continue daily operations as long as they could guarantee employee workplace safety (Mollenkopf et al. 2020; Singh et al. 2020). Consequently, grocery SCs offered unique opportunities to explore SC resilience during the pandemic (Hobbs 2020). Moreover, Italy was one of the first European countries to be hit by the pandemic and also experienced major disruptions related to plant shutdowns and/or truck driver shortages.

Five categories of strategies were identified, corresponding to major streams that companies could pursue to improve their SC resilience: redundancy, flexibility, agility, collaboration, and innovation. Within these larger categories, 21 strategies were also defined to concretely illustrate what actions were taken during the pandemic.

We propose an original taxonomy that could well serve as a tool for investigating ways in which organisations can devise strategies that are able to improve their SC resilience and cope with disruptions. Research findings highlighted that SC resilience encompasses two distinct temporal dimensions that concern not only “when” a strategy is introduced, but also for “how long” it is maintained. Disentangling these two dimensions allowed for pushing forward the theoretical discussion about the strategies’ proactivity or reactivity, thus providing decision-makers and scholars with a new perspective to examine SC resilience.

The paper is organised by first discussing the related literature, followed by a description of the methodology used and a presentation and discussion of the results. Lastly, conclusions are drawn.

2 Related literature

2.1 SC risks and vulnerability

SCs are inherently characterised by uncertainty, as they are exposed to a wide array of possible risks (Christopher and Peck 2004). SC risks can be categorised in many different ways (Christopher and Peck 2004; Kilubi 2016; Jüttner 2005). Among others, scholars distinguish between disruption risks, when they are related to disastrous events caused by either nature or humans, and operational risks, when they arise from variations in supply and demand, human error, and control system failures within SCs (Chen et al. 2013; Knemeyer et al. 2009; Shekarian and Mellat Parast 2020). In more detail, operational risks can be distinguished between supply-side (related to purchasing and supplier relationships) and demand-side (related to downstream SC operations) (Wang and Yu 2020; Jüttner et al. 2003). This study focuses on operational risks since it is devoted to analysing the strategies adopted by firms to cope with disruptions on the supply and demand side during the Covid-19 pandemic.

Closely interconnected with the concept of risk is the notion of SC vulnerability (Colicchia and Strozzi 2012), defined as “an exposure to serious disturbance” (Christopher and Peck 2004, p. 3) whose deviations cause negative effects or consequences.

2.2 SC strategies for resilience

A proven option to face SC vulnerability is resilience (Colicchia et al. 2019; Wieland and Wallenburg 2012). SC resilience can be achieved through a wide set of strategies, i.e., actions aimed at reducing the likelihood of occurrence and the negative effects of risks (Chang et al. 2015; Jüttner et al. 2003) (Table 1). The previous literature offers several contributions that illustrate SC resilience strategies, differing according to how they aim at reducing uncertainty. Five broad categories can be identified (Ivanov et al., 2017): redundancy, flexibility, agility, collaboration, and innovation.

Redundancy strategies focus on mitigating the impacts of negative risk by increasing product availability by “keeping some resources in reserve to be used in case of a disruption” (Sheffi and Rice 2005, p. 44). Increasing strategic inventory, holding safety stock, and maintaining multiple raw materials or logistics services suppliers are the most common forms of redundancy (Kleindorfer and Saad 2005; Singh et al. 2018; Tang 2006b). For example, increasing redundancy through outsourcing to external providers allows for gaining extra capacity when needed, and transforming fixed costs into variable costs (Christopher and Holweg 2011). Moreover, the reduced reliance on single plants or suppliers can be accompanied by rebalancing supply lines to include more local and nearshore suppliers (Agigi et al. 2016; van Hoek 2020a).

In contrast, flexibility strategies consist in building capabilities to sense threats and to respond to them quickly (Chang et al. 2015). Flexibility strategies thus refer to responding to disruptions (i.e., encompassing reactivity), but also include a significant portion of the preparatory components of proactivity (Kilubi 2016). Bulking up inventory across the chain mitigates the risk of stock-outs, and creates the flexibility to fulfil orders from alternate sites in the case of logistics bottlenecks (van Hoek 2020b). This also relates to the concept of postponement to cope with demand uncertainty and geographical disruptions (Battezzati and Magnani 2000; Prataiviera et al. 2020; Tang 2006b). Furthermore, companies might need to focus on critical supplies, and essential products and customers. They could position inventories closer to customers to reduce lead times, or redeploy resources to meet essential demands (Singh et al. 2018).

Close to flexibility, Hosseini et al. (2019) discuss agility as the ability of an SC to respond quickly, smoothly, and cost-efficiently to sudden changes in supply or demand (Wieland and Wallenburg 2013) and the ability to quickly adapt the organisational structure and operations policy as a consequence of turbulent changes (Dubey et al. 2018). This can happen through a set of slick procedures in terms of decision-making processes and policies aimed at reducing the complexity of business operations. Despite the conceptual similarities with flexibility, agility is normally associated with increasing SC responsiveness, highlighting its strong reactive component (Durach et al. 2015; Shekarian and Mellat Parast 2020).

Other strategies involve the interactions among the SC actors as a lever to improve resilience, and these strategies mainly refer to the concept of collaboration (Hosseini et al. 2019; Scholten and Schilder 2015). Collaboration strategies take place through initiatives such as information sharing, visibility, transparency, and the creation of partnerships across the SC to improve the capacity of the SC itself to minimise disruptions, react to risk events, and recover from disruptions (Kilubi 2016; Vilko and Hallikas 2012). Finally, linked to collaboration strategies, the literature also suggests innovation as a way to improve resilience, in particular relating it to the concept of collective process innovation aimed at generating new shared knowledge (Kilubi 2016) and new capabilities that enhance the ability of the SC to quickly react to environmental and market changes (Chen et al. 2013).

Table 1 Categories to group SC resilience strategies

Resilience category	Reference	Definition
Redundancy	Agigi et al. 2016; Chang et al. 2015; Heckmann et al. 2015; Kleindorfer and Saad 2005; Sheffi and Rice 2005; Tang and Tomlin 2008; Tang 2006b; Tomlin 2006; Zhu et al. 2020; Zavala-Alcivar et al. 2020; Hald and Coslugeanu 2021	Recourse to slack capacity, extra resources and back-up plans so that alternative solutions can be rapidly activated in the face of disruptions
Flexibility	Christopher and Peck 2004; Colicchia et al. 2010; Jüttner et al. 2003; Kleindorfer and Saad 2005; Sheffi and Rice 2005; Stone and Rahimifard 2018b; Rajesh 2019; Tang and Tomlin 2008; Tukamuhabwa et al. 2015; van Hoek 2020b; Shama et al. 2020; Zavala-Alcivar et al. 2020; Hald and Coslugeanu 2021	Ability of a firm to change by adjusting the SC configuration
Agility	Braunscheidel and Suresh 2009; Chang et al. 2015; Christopher and Peck 2004; Fadaki et al. 2020; Hohenstein et al. 2015; Mohammed 2020; Sheffi and Rice 2005; Shekarian and Mellat Parast 2020; Stone and Rahimifard 2018; Swafford et al. 2008; Tang and Tomlin 2008; Tomlin 2006; Zavala-Alcivar et al. 2020; Zavala-Alcivar et al. 2020	Ability to respond quickly to unpredictable changes by altering operating states
Collaboration	Barratt et al. 2011; Chang et al. 2015; Chen et al. 2013; Chowdhury and Quaddus 2016; Hallikas et al. 2004; Ho et al. 2015; Jüttner 2005; Jüttner et al. 2003; Kleindorfer and Saad 2005; Lagorio and Pinto 2021; Manuj and Mentzer 2008; Namdar et al. 2018; Pettit et al. 2010; Shekarian and Mellat Parast 2020; Stone and Rahimifard 2018; Tang 2006b; Sharma et al. 2020; Zavala-Alcivar et al. 2020; Hald and Coslugeanu 2021	Capability to work with SC partners for mutual benefit
Innovation	Barcaccia et al. 2020; Golan et al. 2020; Ivanov and Dolgui 2020a; Kamalahmadi and Parast 2016; Ponomarov and Holcomb 2009; Stone and Rahimifard 2018; Tang and Tomlin 2008; Tang 2006b; Zhu et al. 2020; Zavala-Alcivar et al. 2020	Introduction of automation and digitalisation of plants, processes and procedures

2.3 SC resilience and possible approaches

Leveraging on the categories described above, it is important for organisations to adopt a set of strategies which enable a well-rounded approach that develops resilience across its phases: before-disruption (ability to prepare), during-disruption (ability to respond and to recover), after-disruption (ability to maintain and/or grow) (Ali et al. 2017; Hohenstein 2015; Hosseini et al. 2019). Moreover, the moment when a strategy is introduced has usually been matched with the type of approach (proactivity vs reactivity) (Ali et al., 2017; Stone and Rahimifard, 2018). Whether SC resilience is achieved by embracing proactive or reactive strategies is thus considered crucial information in evaluating the type of strategy adopted (Chowdhury and Quaddus 2017; Wieland and Wallenburg 2012).

Proactivity concerns the planning of strategies to absorb disruptions in advance or withstand them with low levels of energy and effort. According to a wider definition, proactive strategies involve the pre-disruption phase, where early planning is needed, and the during-disruption phase, where a minimum level of adaptation is required (Hosseini et al. 2019). Conversely, a narrower definition of proactivity implies that SCs implement pre-disruption measures to cope with turbulence, with no adaptation during times of change (Durach et al. 2015; Kilubi 2016). Incorporating redundancy (Azadegan et al. 2013; Wieland and Wallenburg 2013) and keeping strategic emergency stock (buffer inventory) are generally considered proactive strategies (Sheffi and Rice 2005).

Reactive strategies normally imply that SCs adjust *ex post* to changes. Reactivity involves the during- and post-disruption phases (van Hoek et al. 2001), which corresponds primarily to being flexible and increasing SC agility (Christopher and Towill 2001). However, the system's ability to adapt itself and overcome disruptions implementing effective strategies (Hosseini et al. 2019) often implies that these have been planned in some part. Accordingly, those measures planned and utilised only once the disruption occurs could be considered reactive, from the perspective that reactivity includes some components of proactivity (Kilubi 2016). Due to the ambiguity in definitions, the same strategy could be considered in both proactive and reactive terms (Stone and Rahimifard 2018). For example, multiple sourcing with flexible contracts is either proactive (Hosseini et al. 2019) or reactive (Kilubi 2016).

Overall, it emerges that the boundaries between proactivity and reactivity are now blurred. Therefore, this study classifies resilience strategies into broad categories based on how each of the various approaches aims at reducing uncertainty (Chang et al. 2015), assuming an agnostic position with respect to their proactivity or reactivity.

2.4 Research gap

To date, contributions in the literature have mainly focused on analysing resilience strategies from different perspectives and have tried to encapsulate them into frameworks for classifying their nature. Several research endeavours have tried to measure or quantify resilience before disruptions take place, but we lack details on the specific actions to cope with emergencies, such as Covid-19, which presented unprecedented traits.

Moreover, incomplete and contrasting perspectives coexist about how the type of approach (proactive vs reactive) could match with the temporal dimension of SC resilience strategies (Kilubi, 2016). They mainly depend on the degree of tolerance left in interpreting how proactive strategies need reactive components, and vice versa (Durach et al. 2015, Kilubi 2016, Hosseini et al. 2019). However, companies are adopting a more nuanced approach than before (Roscoe et al. 2020), and scholars could help clarify the blurred boundaries between proactivity and reactivity.

Our purpose is to investigate what SC resilience strategies were introduced during the pandemic and deepen their temporal dimension in relation to the type of approach. We adopted the framework illustrated in Table 2 to classify resilience solutions. In fact, they can be interpreted according to the five literature-based categories, the strategic approach in terms of proactivity or reactivity, and their position against a timeline (before the disruption, during the disruption or after the disruption) to be matched with the four stages of resilience.

Table 2 Dimensions to classify SC resilience strategies

Category	Approach	Timeline
Redundancy	Proactive	Before disruption (Prepare)
Flexibility	Reactive	During disruption (Respond and recover)
Agility		After disruption (Maintain and growth)
Collaboration		
Innovation		

3 Methodology

This study aims at developing broader insights and elaborating previous theory about SC resilience by investigating how companies coped with the pandemic-driven disruption.

The lack of temporal insights about the strategies adopted by organisations to respond to COVID-19 suggests studying these phenomena through a methodology that allows for an in-depth investigation of the underlying mechanisms, creating opportunities for pushing forward theory through the collection of thick empirical data (Flyvbjerg 2006). To get a better understanding of the SC resilience strategies that companies adopted (Barratt et al. 2011) we decided to rely on a qualitative approach based on case studies (Yin 2014), as it allows for exploring a particular phenomenon in its natural settings (Eisenhardt 1989; Ellram 1996; Näslund 2002).

3.1 Research design

The “overall resilience approaches that characterised firms in the grocery industry coping with the COVID-19 pandemic” acted as units of analysis, while the adopted SC resilience strategies represented embedded sub-units of analysis. A multiple-case embedded research design was thus shaped, allowing for a broader exploration while increasing results’ validity and generalisability (da Mota Pedrosa et al. 2012; Ellram 1996).

Grocery SCs were selected as they constitute a large part of consumers’ budgets in all countries (Colicchia et al. 2017) and were hit considerably hard by the pandemic (Barcaccia et al. 2020; Hobbs 2020). Specifically, we focused on the Italian grocery SC, which is included among the top five markets in Europe (Prataviera et al. 2021) and which experienced major disruptions during the pandemic. The selection of cases and informants was guided by the potential to maximise conceptual insights and understanding (Eisenhardt 1989), using purposeful sampling (Patton 1990). The approach of heterogeneous sampling suggested by Saunders et al. (2009) was applied, targeting 34 Italian companies, including both manufacturers and retailers, and choosing large companies, as they are usually more prone to formalise and develop SC resilience (Roscoe et al. 2020).

These companies were approached through contacts activated by two Italian universities in collaboration with GS1 Italy, which is the main trade association of peers in the grocery industry in Italy: 21 companies (15 manufacturers and 6 retailers) accepted the invitation to participate. Due to the sensitive nature of the topic, confidentiality was guaranteed to interviewees and, therefore, neither company nor individuals’ names will be revealed. Including both manufacturers and retailers made it possible to collect data about heterogeneous SC perspectives in the panel (Ellram 1996; Voss et al. 2002) and increased the external validity of the research (Caniato et al. 2018; Ellram 1996).

Research rigour was ensured through the development of a research protocol that included key research issues, the proposed methodology, and the interview guide (Yin 2014). This supported the study’s external validity and reliability, allowing experiments to be repeated following the same guidelines (Ellram 1996). The interview guide (Appendix A), which was developed on the outcomes of the literature review, allowed data to be collected directly from managers. A pilot study was rolled-out to improve and refine the research protocol (Caniato et al. 2018; Voss et al. 2002) and applied to four pilot cases (two manufacturers and two retailers) in July 2020. Data collection then took place between August and October 2020.

3.2 Data collection

Empirical data was collected through semi-structured interviews (Voss et al. 2002), with an average duration of 120 minutes. Multiple interviewees were involved to enhance construct validity (Ellram 1996). To ensure an adequate understanding of the problem, primary informants were senior logistics and SC managers (Table 3). For each case, the SC manager or director and the logistics managers were interviewed, while only for the manufacturers was the production manager also interviewed.

Table 3 Panel characteristics

Firm	#Informants	Key informant's role
MAN1	4	Customer Service Manager
MAN2	3	SC Director
MAN3	3	SC Manager
MAN4	3	Physical Distribution & Transportation Manager
MAN5	3	Group Logistics Manager
MAN6	4	Customer Innovation Manager
MAN7	4	Logistics Manager
MAN8	3	SC Manager
MAN9	3	SC Manager
MAN10	3	Logistics Manager
MAN11	4	Key Customer Logistics Senior Manager
MAN12	4	SC Manager
MAN13	3	SC Manager
MAN14	4	Logistics and Customer Service Manager
MAN15	3	Logistics Manager
RET1	2	SC Manager
RET2	2	SC Manager
RET3	2	Logistics Manager
RET4	3	Logistics Manager
RET5	2	SC Manager
RET6	2	SC Manager

The recourse to multiple interlocutors helped corroborate the evidence and reduce information bias risk (Yin 2014). Multiple investigators were also involved to enhance the convergence of observations and increase confidence in the findings (Voss et al. 2002), and to enhance the creative potential of the team (Yin 2014).

The interview guide included a list of 7 questions developed according to the funnel format (having broad, open-ended questions which were followed by more detailed and specific questions) (Voss et al. 2002). A

structured case outline was prepared and progressively updated to improve research rigour and facilitate data collection (Eisenhardt 1989; Ellram 1996). This allowed data overload to be avoided, facilitating data classification, and supporting the subsequent data analysis (Yin 2014).

The interview guide was shared in advance to facilitate the collection of a more accurate, varied, and detailed set of information, thus increasing the quantity and the quality of the collected data (Yin 2014). Internal validity was supported by using categories derived from the literature and then by triangulating data collected through interviews with secondary sources (Ellram 1996), such as industry reports, trade magazines, and newspapers. Data triangulation also allowed improvement of the study's construct validity (Eisenhardt 1989). Each case study was reviewed by each researcher that attended the interview, and the documentation was sent back to the firms' key informants to increase the study's reliability (Yin 2014).

3.3 Data analysis

The within-case analysis represented the first step of data analysis (Dubois and Araujo 2007). The main objective was data reduction and standardisation within each case study (Eisenhardt 1989; Näslund 2002). A provisional starting list of coding dimensions was built upon the literature and updated during the four pilot cases (Table 4). For example, we first considered the traditional dichotomy between proactivity and reactivity, but later explicitly introduced the moment in which the solution was conceived (*timing*) and further detailed this temporal perspective by investigating for how long each solution was going to be adopted (*duration*).

Table 4 Coding dimensions and related characterisation

Coding dimensions	Related question	Alternatives		
Company Approach	What is the underlying approach?	Proactive	Reactive	
Timing	When was the solution conceived?	Prior to Covid-19	During the first wave of Covid-19	After the first wave of Covid-19
Duration	How long is it going to be adopted for?	Temporary	Permanent	

To enhance the study's reliability (Ellram 1996), the company reports that resulted from the within-case analysis were consolidated into the study database, which included all the strategies collected and the related explanatory notes and quotes. This allowed a cross-case analysis to be performed to find similarity and difference patterns between different strategies and companies, enhancing external validity (Voss et al. 2002).

Data was analysed by iteratively applying open and axial coding to develop relevant categories (Ellram 1996). When two or more strategies were recognised as conceptually similar, they were associated with the same higher-level category. For example, the activation of additional suppliers of raw materials during the first wave of Covid-19 or the adoption of multiple sourcing prior to the pandemic were consolidated into the same standard solution of "Multiple Sourcing". New information was constantly compared with what was previously collected, and categories were updated whenever meaningful insights emerged (Yin 2014). For example, the concept of fungibility was first related to the well-known flexibility construct, and later elaborated to acknowledge its different characteristics. Different organisations provided details on the SC resilience strategies, showing that within each resilience category "standardised" solutions could be identified across the sample. This allowed for significantly reducing the amount and variety of information to be managed, improving understanding and supporting later dissemination by increasing the study's practical relevance (Stentoft and Rajkumar 2018).

Also, by interpreting contextual idiosyncrasies as empirical elaborations of more general categories, a sense of generality was established, and the duality criterion proposed by Ketokivi and Choi (2014) was met.

4 Findings

This section presents the outcomes of the within-case analysis based on the template of Table 4 (which has been expanded in Appendix B), while the collected resilience strategies are reported and classified in Table 5.

Table 5 Strategies adopted to increase SC resilience with the outbreak of the COVID-19 pandemic

Category	Strategy
Redundancy	Multiple sourcing
	Buffer capacity
Flexibility	Switch of logistics flows
	Inventory planning
	Transport routing
	Order management
	Plant fungibility
	Product fungibility
	Workforce fungibility
Agility	Product range rationalisation
	Promotional activity
	Batch size
	Decision making process
	Streamline logistics
Collaboration	Collaborative planning
	Collaborative delivery
	Information flow digitalisation
	Financial support
Innovation	Warehouse automation
	Omni channel
	SC analytics

4.1 Redundancy

Redundancy was introduced leveraging multiple sourcing and buffer capacity for raw materials, packaging, finished products, and logistics services. Respondents mostly acted proactively, having already introduced redundancy prior to the spread of Covid-19. As claimed by the SC manager of RET5, “*We have multiple suppliers for some specific products. During Covid-19, the volumes supplied by secondary suppliers increased due to the crisis of the primary ones.*” More than three-quarters of the firms had identified different possible suppliers before the pandemic spread, but some activated multiple sourcing only after the crisis outbreak, relying on pre-pandemic agreements. Contrarily, one quarter of the interviewees implemented this strategy reactively, looking for new suppliers only at the start of the Covid-19 outbreak. As acknowledged by the SC manager of RET6, “*On Thursday, we registered an explosion in the demand for flour, and by Monday we had to find an alternative supplier using our network of relationships.*” More than two-thirds of our interviewees used the strategy temporarily and dismissed it after the emergency, while the others evaluated it as permanent.

The majority of respondents achieved redundancy by creating buffer capacity through the introduction of safety stocks, additional workforce, and the activation of alternative storage spaces. Half of the companies had proactively introduced these strategies before the pandemic. For example, the logistics manager of MAN15 stated that “*Having precautionary in-house safety stocks helped us satisfy the demand explosion, without developing ad hoc initiatives during the pandemic.*” However, there were also cases in which they were activated directly during the emergency and only temporarily (e.g., use of alternative storage spaces, additional workforce).

4.2 Flexibility

During the pandemic, companies implemented flexible strategies focusing on dynamic planning and fungibility. Dynamic planning strategies aimed at increasing the flexibility of the logistics flows (i.e., transport routing and switch of logistics flows), inventory network planning, and order management decisions. Companies mainly adapted their routes by relying on intermodal transportation to overcome the closure of international borders and the switch of logistics flows. This was done, for example, by operating a re-allocation of the departure and delivery nodes. As stated by the SC manager of RET2, “*We were not used to dealing with direct deliveries to retail stores, but for some fast-selling products (e.g., mineral water) it was necessary to guarantee a fast supply to shops.*” Companies also increased the flexibility of the inventory network through the upward or backward reallocation of stock, or reviewed the customers’ order allocation policy by prioritizing the orders of top customers. Dynamic planning strategies were activated both before and during the pandemic, being supported by pre-disruption settings.

In other cases, they were introduced for the first time during the emergency, and only temporarily (e.g., order management). These firms said they were going to restore the prior Covid-19 network organisation, despite being ready to re-introduce these strategies if needed.

Concurrently, half of the respondents developed strategies dealing with fungibility, i.e., the concept of substitutability among products, plants and people. During the pandemic, producers reconverted production lines to switch some product categories from one line to another, or they reallocated personnel to the most critical departments. For example, the logistics manager of RET3 declared that *"The cashiers who worked in the non-food department were relocated to perform picking activities in the click & collect area."* Since medium-large investments are necessary to make and implement fungibility strategies, more than half of the respondents introduced them proactively. Companies highlighted that these strategies sometimes entailed taking sub-optimal decisions which increased internal costs; they were, therefore, activated only for the short term.

4.3 Agility

Respondents also resorted to strategies focusing on agility based on decomplexity and streamlining. Decomplexity strategies entailed activity simplification through product range rationalisation, promotional activity reduction, and optimisation of batch size in production and logistics processes. As explained by the SC manager of MAN12, *"Because we were not able to supply the entire product range, we agreed with customers on the most important items."* Concerning rationalisation of the product range and the reduction of promotional activity, companies reactively conceived and activated them only once the pandemic spread, with the intention of restoring things back to "normal" after the emergency to avoid losing profits. To simplify logistics and production processes, companies introduced batch size optimisation. As explained by the SC manager of RET2, *"During the emergency, we modified the reordering parameters to increase the reordering percentage to whole pallets, reducing the complexity of picking."* In half of the cases, the strategy was introduced proactively before the pandemic and used either on an ongoing basis or temporarily if needed; in the others, it was implemented reactively after the pandemic spread, while being willing to dismiss it in the near future.

Companies also implemented strategies to increase the speed of internal decision-making and logistics processes. Decisions were streamlined by simplifying the internal bureaucracy, and formalising and updating business continuity protocols. Two-thirds of companies were well-prepared for the emergency (e.g., having already introduced Business Continuity Plans), but one-third relied on a completely reactive approach. Nevertheless, three-quarters of the companies said they were willing to implement these strategies permanently, strengthening business continuity plans and simplifying the daily decision-making processes. In addition, respondents also adopted logistics streamlining strategies by reviewing order fulfilment timing (e.g., extension of receiving time windows at DCs, postponement of orders cut-off). As explained by the customer innovation manager of MAN6, *"Due to the increase in volumes we decided to revise the delivery logic by extending the delivery windows to customers on Saturdays and Sundays."* Half of them had already relied on these strategies in the past; however, they were meant to be activated only in case of emergency and temporarily.

4.4 Collaboration

More than three-quarters of the companies adopted strategies to improve collaboration during the pandemic. Manufacturers and retailers increased information sharing about order planning, logistics flows and inventory levels to better align demand and supply. One fifth of the respondents implemented collaborative delivery strategies and introduced dedicated unloading slots and the "free-pass" modality for certified deliveries. More than half of the companies digitalised information flows, or relied on the Electronic-Data Interchange (EDI). Companies also leveraged more sophisticated inventory management systems, such as Vendor Managed Inventory (VMI). More than one-third introduced financial collaboration strategies, i.e., reduction of supplier's payment terms and extension of customer's payment terms. These types of strategies were adopted both proactively and reactively. Some of them required significant time and cost investments (e.g., VMI, digitalisation), thus needing to be widely discussed, economically evaluated, and then implemented prior to the advent of Covid-19. Other strategies (e.g., financial support) were implemented reactively within a few weeks and were limited to the emergency. More than two-thirds of the companies were keen to keep collaborative planning and collaborative logistics strategies based on digitalisation permanently in their organisations, and they highlighted the need to strengthen them in the future. As acknowledged by the logistics manager of MAN7, *"Little has been done about collaboration and digitisation but we need to take a step forward to improve"*, while the logistics manager of MAN15 claimed that *"this period has taught us that collaboration and digitalisation can lead to more effective and faster information."*

4.5 Innovation

Companies also developed innovative capabilities, regarding warehouse automation, e-commerce deliveries, and SC analytics tools. Approximately half of the respondents had implemented materials handling automation systems for the storage, handling and picking of goods, together with innovative solutions (e.g., IoT and RFID) inside warehouses before the pandemic. This enabled them to speed up logistics processes and to guarantee business continuity in case of workforce absenteeism, which proved to be highly important during the pandemic. As reported by the SC manager of RET6, *“During the pandemic, warehouse automation allowed us to keep operations running without people or with reduced staff. We were able to cope with double layer orders thanks to the presence of a robot for layer picking. In the future, we plan to extend automation to other warehouses”*. At the same time, more than half of the manufacturers and retailers empowered the e-commerce channel to cope with the strong increase in online orders in March-April 2020. The recourse to SC analytics tools, entailing scenario-based simulation capabilities, demand sensing, and predictive analytics models, improved the management of demand variations. As stated by the logistics manager of MAN7, *“During the pandemic, we were able to secure a reduction in stock-out and over-stock costs by focusing on increasing forecast accuracy through the adoption of advanced systems coupled with robust Sales & Operations Planning processes.”* These strategies normally require large investments, and two-thirds of the companies had already introduced them prior to Covid-19 to keep them permanently in their business structure. Our interviewees highlighted that it was not possible to quickly introduce them on a totally reactive basis. In a few cases only, respondents relied reactively on the development of basic SC analytics tools, developing what-if scenario simulations based on spreadsheet tools.

Lastly, innovation strategies could enhance resilience both during the Covid-19 pandemic and for the future. In fact, more than half of the respondents expressed the need to further empower them in the medium-long term.

5 Discussion

5.1 SC resilience strategies

The companies interviewed adopted a rich and heterogeneous set of strategies to face the disruptions caused by the COVID-19 pandemic, and redundancy and flexibility strategies were confirmed as key elements of most SC resilience approaches (Ponomarev and Holcomb 2009; Wieland and Wallenburg 2012). During the COVID-19 pandemic, companies activated back-up plans (redundancy), adopting strategies based on multiple sourcing or additional inventory (Colicchia et al. 2011; Kleindorfer and Saad 2005; Tang 2006b; Tomlin 2006). In addition, they rapidly adapted their processes (flexibility) to the fast-changing and highly unpredictable environment, increasing the adaptability of logistics flows and of the order fulfilment process (Kleindorfer and Saad 2005; Namdar et al. 2018; Sheffi and Rice 2005). Interviews also confirmed the importance of collaborative strategies to enhance resilience (Chang et al. 2015; Kilubi 2016; Shekarian and Mellat Parast 2020), as firms became more collaborative with their SC partners to mitigate the impacts of Covid-19.

On the other hand, our research enriches the current literature by highlighting the relevance of “fungibility” strategies to increase the flexibility of SC and operations processes (recalling what other scholars called “substitutability”, e.g., Rao and Goldsby (2009); Stevenson and Spring (2007)). Case studies revealed that companies pushed forward agility strategies, leveraging streamlining and simplifying SC operations (Christopher and Peck 2004; Kembro and Norrman 2020). Moreover, findings illustrate that technological advancements have encouraged firms to implement innovative internal and external strategies that could reinforce SC resilience (Barcaccia et al. 2020; Stone and Rahimifard 2018). Such strategies concerned the introduction of automation and the digitalisation of facilities, processes and procedures that could improve the effectiveness and efficiency of the involved players, while simultaneously creating the opportunity to be more resilient (Golan et al. 2020; Ivanov and Dolgui 2020a; Zhu et al. 2020). In addition, the pandemic created an urgency to empower e-commerce solutions (Ivanov and Dolgui 2020a; Lagorio and Pinto 2021; Sarkis 2020; Wang et al. 2020), which proved to be particularly pervasive during the first wave of the COVID-19 pandemic.

5.2 An original taxonomy for classifying SC resilience strategies according to the temporal dimension

An element of novelty that characterised our investigation concerns the temporal dimension of the different SC resilience strategies. According to the previous literature, strategies can be distinguished into those that are introduced before, during, or after a disruption (Hosseini et al. 2019), and this has traditionally been matched with the type of adopted approach (proactivity versus reactivity) (Ali et al. 2017; Stone and Rahimifard 2018). However, the verbatim application of these concepts to our findings is not straightforward, as different companies interpreted the same strategies in different terms. For example, the activation of back-up plans could refer to decisions made either before the disruption (implying proactivity) or upon the disruption (implying reactivity). Moreover, it appears that resilience strategies have a sort of “life-cycle”. Our findings suggest that strategies were activated at a certain moment in time and were used within a certain time window. This observation suggests that the temporal

dimension of resilience strategies can be represented by two sub-dimensions: a specific time point (“when”, i.e. activation) and a time window of usage (“how long”, i.e. duration).

We developed a matrix (Fig. 1) to display that the “when” sub-dimension contains two further layers of differentiation, which take into account when the solution was conceived (before or during disruptions) and when the solution was activated by the firm (before, during or post disruptions). The moment when a strategy is conceived (which could happen before a given disruption) might not be the same as that when the strategy is concretely activated (which instead could occur upon a disruption). Findings revealed that some strategies were designed before the pandemic, with the possibility to rely on ex-ante setting structures but were activated only once the emergency spread. For example, many companies highlighted their purpose to streamline decision-making processes to improve SC resilience, having conceived this strategy before the pandemic. However, only upon the disruption did they concretely update internal procedures to quickly address the contingent crises introduced by the pandemic. Other companies both conceived and activated a set of strategies before the pandemic. As a result, they have been able to withstand negative impacts with less effort and without the need to widely adapt their structure (Hosseini et al. 2019). A common thread regarding these strategies is that they generally require the medium-long term to be implemented (e.g., buffer capacity or warehouse automation), making it challenging to activate from scratch such strategies in case of emergency. In a different fashion, to quickly adjust and preserve the continuity of the business, some companies reacted to the Covid-19 emergency by activating strategies that were designed from scratch during the crisis (Ali et al. 2017). Along with pre- and during-activation strategies, some strategies were planned to be activated in the post-disruption phase. Companies had already started to design them before the pandemic or, in other cases, they were conceived during the pandemic to leverage the lesson learned from the disruptions experienced (Ali et al. 2017; Ponomarov and Holcomb 2009).

As far as the identified second temporal sub-dimension (“how long”) is concerned, we identified two further layers that distinguish whether strategies were available or were actually used. We reported these further layers of the “how long” sub-dimension in a matrix (Fig. 2). This further distinction displays how strategies are applied in the different cases, separating strategies utilised on a temporary or permanent basis, and strategies temporarily or permanently at the disposal of the organisation. While some strategies were already used as permanent parts of a company’s organisation, other companies implemented strategies with temporary duration, and these were used as long as the emergency lasted and were dismissed once the pandemic had subsided. They represented a quick response to lessen the impact of the disruption or to change its effect (Ali et al. 2017). In many cases, companies do not need to rely on a background structure and can resort to them according to the principle of facing “Just in Case” uncertainties (Phadnis and Joglekar 2021). For example, some companies interpreted multiple sourcing as the activation of a supplier for the first time during the pandemic with the intention to stop the contract after the emergency. Lastly, firms resorted to solutions that they have permanently available to be temporarily activated in case of disruption. In this case, firms relied on pre-pandemic strategies and decided to use them temporarily only once the pandemic spread, with a plan to deactivate (but not cancelling) them at the end of the emergency.

5.3 Proactivity and reactivity

By combining the two temporal sub-dimensions “when” and “how long” we formalise a taxonomy that offers an original perspective to address SC resilience. It emerged that the same strategy can be positioned in more than one quadrant according to the different adoption cases (Fig.1 and Fig.2). Consequently, the same resilience strategies can be interpreted differently by different companies, according to their temporal characterisation and depending on the way they are conceived, activated, and for how long they are available and used.

Although our taxonomy confirms the relevance of the temporal dimension (Ali et al. 2017; Kilubi 2016; Kleindorfer and Saad 2005), it also unveils a blurrier distinction between proactivity and reactivity in comparison to the findings of previous research (which generally associates proactivity with the “pre-disruption” timestamp and reactivity with the “during” or “post-disruption” timestamp). As displayed in Fig. 3 and Fig. 4, and referring to the time-window of the Covid-19 emergency, strategies that were both designed and activated before the disruption can be considered purely proactive. Also, companies that relied on strategies that were permanently available and permanently utilised in the organisation showed a proactive approach towards the emergency, in line with the “prepare” phase of resilience (Hohenstein et al. 2015). On the other hand, strategies conceived and applied during a disruption, or temporarily used and made available, present a pure reactive approach to “respond” and “recover” (Hohenstein 2015). Between pure proactivity and pure reactivity, there is a set of “hybrid” approaches encompassing strategies that require some preparatory components, typical of proactivity, and a portion of adaptive components, typical of reactivity (Kilubi 2016). This is the case for strategies that were proactively conceived before the emergency but were activated reactively during or after the disruption (Hohenstein 2015). Strategies that were reactively conceived during the disruption but were to be activated in the post disruption phase to proactively “maintain” and “grow” resilience fall into this hybrid category, too. It is also the case for strategies that were permanently available in the organisations but were only utilised temporarily in case of need.

The examination of the link between the temporal dimension and the proactive or reactive approach confirms that the same strategies can be proactive, reactive or hybrid for different companies. For example, multiple sourcing can be implemented reactively in a few days in the case of an extemporary supplier to be used for a very short period just to withstand the emergency. Conversely, establishing a long-term partnership with an alternative supplier to diversify the supply basis normally requires proactivity. Consequently, strategies can be positioned as proactive, reactive, or hybrid according to the specific application context and the desired output. These considerations apply to the specific “time-window” of the considered emergency. If we extend the view beyond the crisis, resilience strategies with the typical traits of reactivity in the emergency (e.g., rapidly conceived and applied only after the disruption) could, instead, represent proactive strategies to be more prepared in the near future to cope with unexpected events (Ponomarov and Holcomb 2009). This is representative of the “reactive capability required after a SC event to understand what has happened and improve future performances based on experience” (Ali et al. 2017, p. 23).

6 Conclusions

This study aimed at investigating which SC resilience strategies were introduced by grocery companies during the Covid-19 pandemic with respect to their temporal dimension and also in relation to the type of approach (proactive versus reactive). The Italian grocery SC was considered in a multiple case research that involved 21 organisations (manufacturers and retailers). Findings revealed empirical evidence supporting the five categories of strategies developed within the academic literature. They confirmed the importance of redundancy and flexibility (Ponomarov and Holcomb 2009; Wieland and Wallenburg 2012), and the relevance of collaborative strategies to enhance resilience (Shekarian and Mellat Parast 2020). They also highlighted the need to streamline operations to increase SC agility (Christopher and Peck 2004; Kembro and Norrman 2020) and showed how technological advancements were helpful to introduce innovative strategies that reinforce SC resilience (Barcaccia et al. 2020). Lastly, our investigation highlighted original facets regarding the temporal dimension of the different SC resilience strategies (Kilubi 2016; Ali et al. 2017), which have theoretical and practical implications.

6.1 Theoretical implications

This study contributes to theory by extending the current knowledge on the topic of SC resilience. First, we provide a thorough analysis of the adopted resilience strategies in case of emergencies, thus supporting, integrating and synthesizing the catalogue of strategies present in the existing literature. In addition, our work suggests that the abundance of theoretical contributions still lacks clarity about the temporal dimension of the resilience strategies. For this reason, we propose an original taxonomy that introduces two new dimensions related to the timing (“when?” and “how long?”), each of them complemented by other sub-dimensions that explain respectively the conception and activation, and the utilisation and availability of the strategies. This taxonomy helps better understand how the temporal dimension of strategies cannot be seen as a “simple” matter of “pre/during/post” disruption, but presents more articulated features. Our analysis reveals that multiple layers are necessary to comprehensively describe the temporal dimension of SC resilience strategies. A traditional “static snapshot” of a resilience strategy might be unable to embrace the features and the adoption mechanisms of a specific strategy. In this way, we do not simply provide “another” taxonomy, but we contribute by shedding light on the need to extend the traditional “static” analysis of resilience strategies and move towards a more “dynamic” consideration of the conception, use, and availability of SC resilience strategies.

The analysis of the timing also allowed contribution to the debate on the approaches to SC resilience in terms of proactivity and reactivity. Our analysis shows that a specific strategy can be purely proactive, purely reactive, or even hybrid. Based on the analysis of the temporal dimension, it emerges that the boundary between proactivity and reactivity is increasingly blurred, and the distinction between proactive and reactive approaches is no longer sufficient to exhaustively explain the nuances of resilience strategies.

6.2 Managerial implications

From a managerial perspective, we provided the industrial community with a consistent and synthesised set of SC resilience strategies adopted by organisations when facing unpredictable and global disruptions. This goes in the direction of the generation of the so-often advocated “shared knowledge” that helps organisations in facing disruptions and risks by relying on the experience of peers and others (Tao et al. 2016). Our analysis suggests that companies have a wide array of potential choices at their disposal to develop resilience strategies. This array can comprise several actions and initiatives in a mixture of proactive and reactive strategies, as seen with the companies in this study, which resorted to more than one category of strategies, using various reactive and proactive approaches and with varied temporal characterisations.

We also provide a taxonomy that represents a tool to better understand the choices in terms of approaches to resilience, thanks to the subdivision of the temporal dimension into two sub-dimensions. It could help increase companies' awareness of the fact that resilience strategies can co-exist and change over time as the nature of the external business environment varies (Roscoe et al. 2020). In this sense, a reactive strategy adopted during the pandemic could become a future proactive strategy for being prepared for the next disruption.

Hence, our study provides an overview of how companies could shape their risk management approach to cope with unpredictable disruption risks in the future. By decoupling the traditional view that associates a strategy with a type of approach, our study could encourage companies to rethink the set of strategies they can use to cope with a crisis. It might also push them to develop a risk management culture that empowers the definition and planning of resilience strategies before risk events take place (prepare) but which also encompasses the activation or redesign of actions during the disruption to recover from it (respond and recover). This could potentially devise further initiatives after the disruptions have occurred, with the aim to consolidate the newly acquired equilibrium in a dynamic way (maintain) (Davoudi et al. 2012) and to learn from the unexpected events to develop preparedness for the future (growth) (Hohenstein et al. 2015).

6.3 Limitations and future research directions

This study is not exempt from limitations. First, the sample size limits the findings' generalisation as the investigated companies include only manufacturers and retailers. Moreover, even if the grocery SC represents a significant and critical application field, it includes considerations that might be valid only for the specific features of this industry (e.g., product range prioritisation). Future research can compensate for the limitations of the present work by extending the sample size to embrace more variety and additional facets of the topic, and other critical industries could be the object of similar studies. It is true, however, that the data collection tool and the data analysis protocol developed in this research are not specific to the grocery supply chain or to a specific emergency. The interested reader can refer to Appendix A – where, for example, the references to Covid-19 can be substituted with references to any other disruption or risk event, and to Appendix B – where the coding dimensions present traits that make them suitable to other different sectors.

Although this study contributes to bridging the gap in place between academic studies and industrial practice, we did not scrutinise the antecedents of the decisions made by companies in selecting the adopted resilience strategies. It would be interesting to examine the antecedents of the design and utilisation/activation of resilience strategies, especially in light of the Contingency Theory that invites companies to rethink their managerial decisions based on the continuous evolution of their operating environment. Since our findings suggest that SC resilience strategies often co-exist and change over time as the nature of the external business environment alters, this theory could be the pivot in driving the analysis and interpretation of the mechanisms leading to the management of SC risks and related disruptions through appropriate resilience strategies.

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Table 1 Categories to group SC resilience strategies

Resilience category	Reference	Definition
Redundancy	Agigi et al. 2016; Chang et al. 2015; Heckmann et al. 2015; Kleindorfer and Saad 2005; Sheffi and Rice 2005; Tang and Tomlin 2008; Tang 2006b; Tomlin 2006; Zhu et al. 2020; Zavala-Alcívar et al. 2020; Hald and Coslugeanu 2021	Recourse to slack capacity, extra resources and back-up plans so that alternative solutions can be rapidly activated in the face of disruptions
Flexibility	Christopher and Peck 2004; Colicchia et al. 2010; Jüttner et al. 2003; Kleindorfer and Saad 2005; Sheffi and Rice 2005; Stone and Rahimifard 2018b; Rajesh 2019; Tang and Tomlin 2008; Tukamuhabwa et al. 2015; van Hoek 2020b; Sharma et al. 2020; Zavala-Alcívar et al. 2020; Hald and Coslugeanu 2021	Ability of a firm to change by adjusting the SC configuration
Agility	Braunscheidel and Suresh 2009; Chang et al. 2015; Christopher and Peck 2004; Fadaki et al. 2020; Hohenstein et al. 2015; Mohammed 2020; Sheffi and Rice 2005; Shekarian and Mellat Parast 2020; Stone and Rahimifard 2018; Swafford et al. 2008; Tang and Tomlin 2008; Tomlin 2006; Zavala-Alcívar et al. 2020; Zavala-Alcívar et al. 2020	Ability to respond quickly to unpredictable changes by altering operating states
Collaboration	Barratt et al. 2011; Chang et al. 2015; Chen et al. 2013; Chowdhury and Quaddus 2016; Hallikas et al. 2004; Ho et al. 2015; Jüttner 2005; Jüttner et al. 2003; Kleindorfer and Saad 2005; Lagorio and Pinto 2021; Manuj and Mentzer 2008; Namdar et al. 2018; Pettit et al. 2010; Shekarian and Mellat Parast 2020; Stone and Rahimifard 2018; Tang 2006b; Sharma et al. 2020; Zavala-Alcívar et al. 2020; Hald and Coslugeanu 2021	Capability to work with SC partners for mutual benefit
Innovation	Barcaccia et al. 2020; Golan et al. 2020; Ivanov and Dolgui 2020a; Kamalahmadi and Parast 2016; Ponomarov and Holcomb 2009; Stone and Rahimifard 2018; Tang and Tomlin 2008; Tang 2006b; Zhu et al. 2020; Zavala-Alcívar et al. 2020	Introduction of automation and digitalisation of plants, processes and procedures

Table 2 Dimensions to classify SC resilience strategies

Category	Approach	Timeline
Redundancy	Proactive	Before disruption (Prepare)
Flexibility	Reactive	During disruption (Respond and recover)
Agility		After disruption (Maintain and growth)
Collaboration		
Innovation		

Table 3 Panel characteristics

Firm	#Informants	Key informant's role
MAN1	4	Customer Service Manager
MAN2	3	SC Director
MAN3	3	SC Manager
MAN4	3	Physical Distribution & Transportation Manager
MAN5	3	Group Logistics Manager
MAN6	4	Customer Innovation Manager
MAN7	4	Logistics Manager
MAN8	3	SC Manager
MAN9	3	SC Manager
MAN10	3	Logistics Manager
MAN11	4	Key Customer Logistics Senior Manager
MAN12	4	SC Manager
MAN13	3	SC Manager
MAN14	4	Logistics and Customer Service Manager
MAN15	3	Logistics Manager
RET1	2	SC Manager
RET2	2	SC Manager
RET3	2	Logistics Manager
RET4	3	Logistics Manager
RET5	2	SC Manager
RET6	2	SC Manager

Table 4 Coding dimensions and related characterisation

Coding dimensions	Related question	Alternatives		
Company Approach	What is the underlying approach?	Proactive	Reactive	
Timing	When was the solution conceived?	Prior to Covid-19	During the first wave of Covid-19	After the first wave of Covid-19
Duration	How long is it going to be adopted for?	Temporary	Permanent	

Table 5 Strategies adopted to increase SC resilience with the outbreak of the COVID-19 pandemic

Category	Strategy
Redundancy	Multiple sourcing
	Buffer capacity
Flexibility	Switch of logistics flows
	Inventory planning
	Transport routing
	Order management
	Plant fungibility
	Product fungibility
	Workforce fungibility
Agility	Product range rationalisation
	Promotional activity
	Batch size
	Decision making process
	Streamline logistics
Collaboration	Collaborative planning
	Collaborative delivery
	Information flow digitalisation
	Financial support
Innovation	Warehouse automation
	Omni channel
	SC analytics

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Fig. 1 “When” matrix

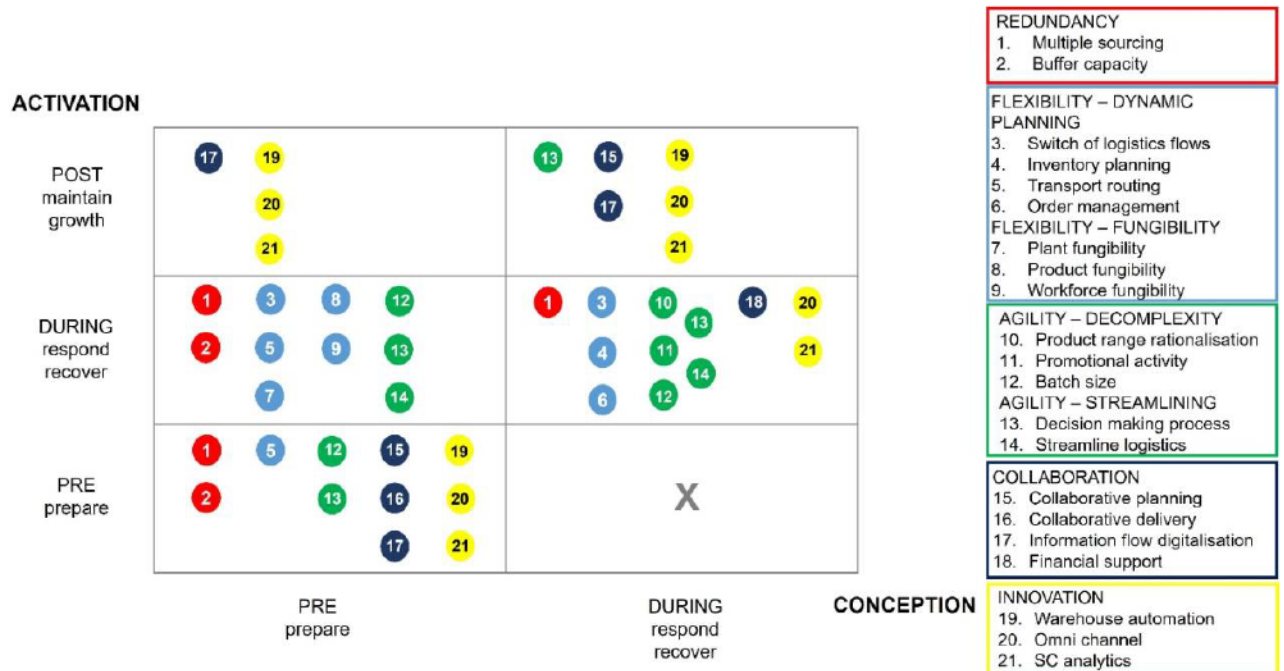


Fig. 2 “How long” matrix

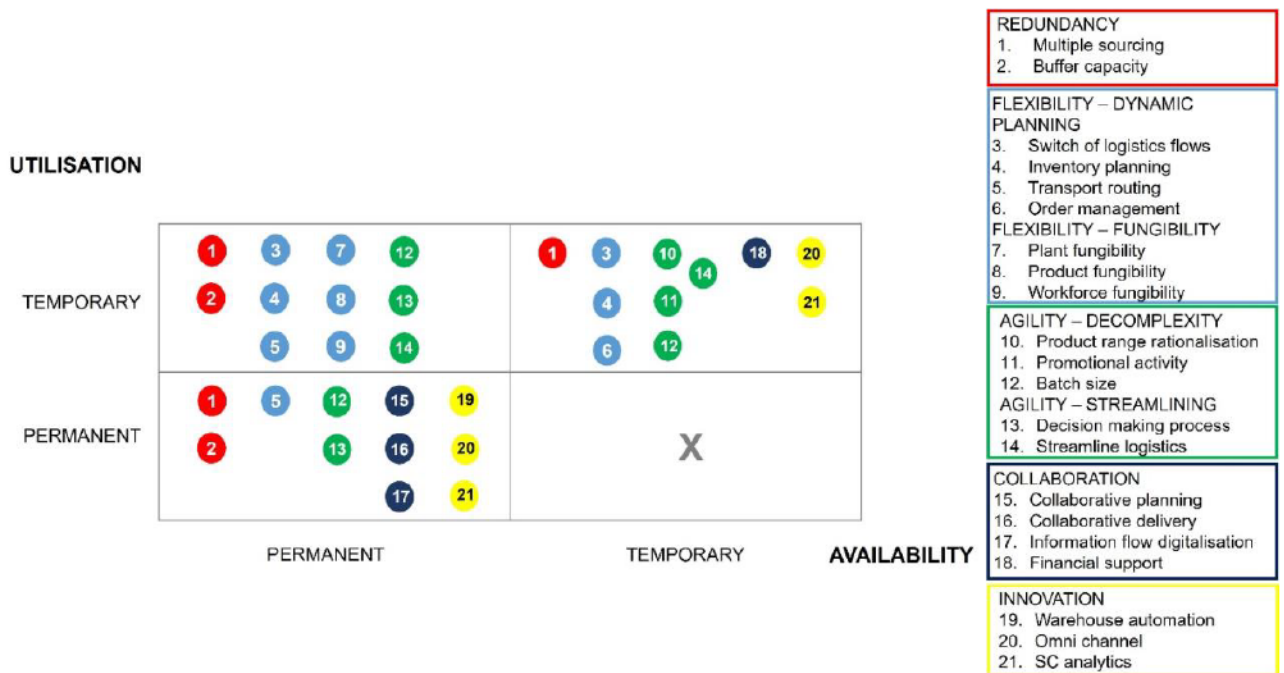


Fig. 3 “When” matrix and the type of approach

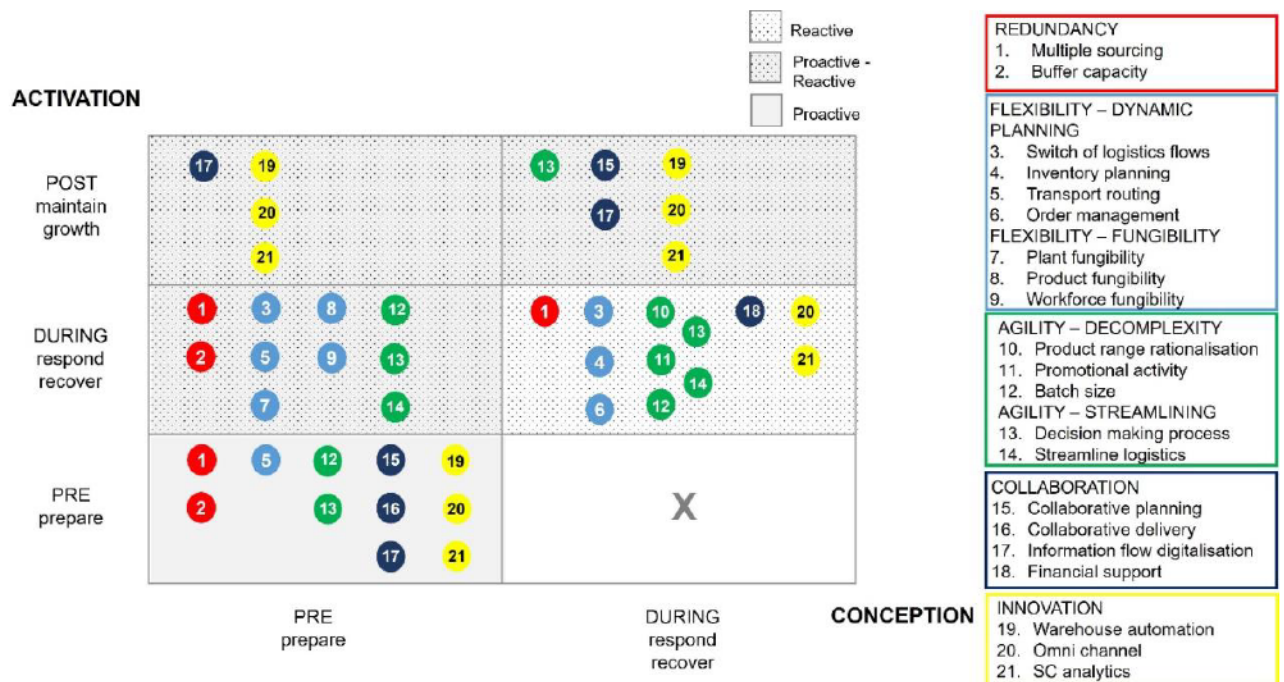
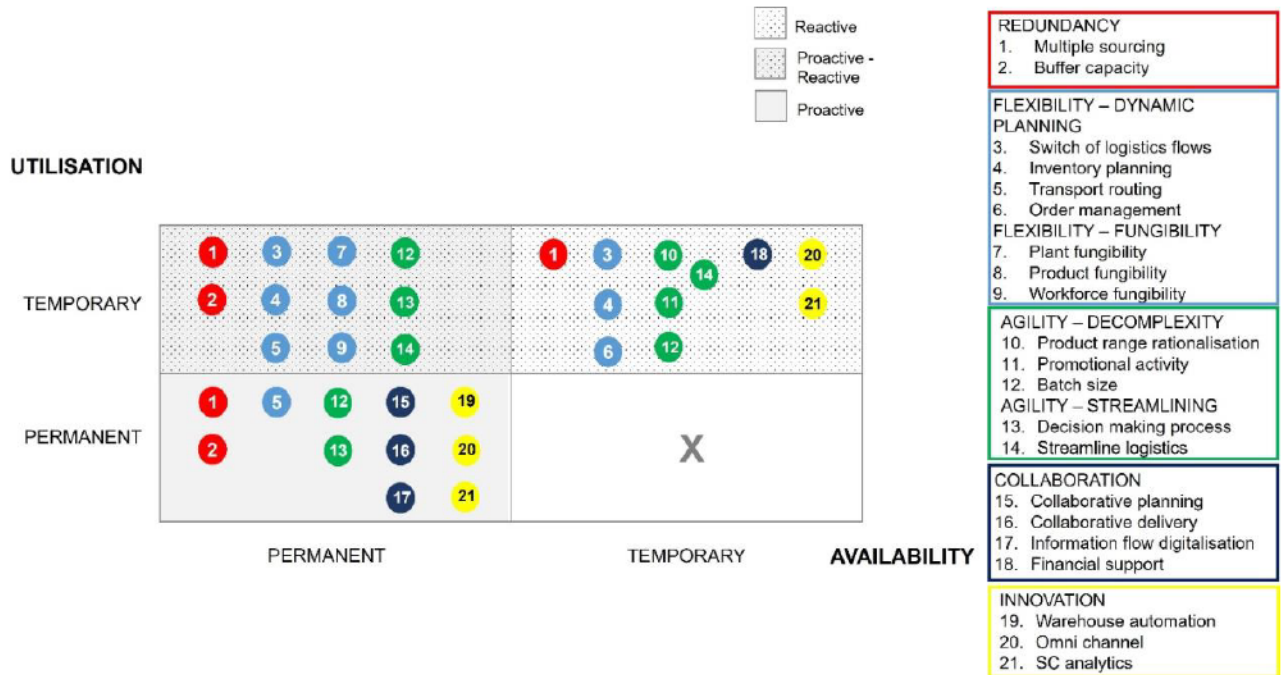


Fig. 4 “How long” matrix and the type of approach



Appendix A - Interview guide

Resilience strategies could be categorised according to five categories (redundancy, flexibility, agility, collaboration, innovation).

1. What are the resilience strategies that were helpful in mitigating the COVID-19 effects?
2. What was the underlying approach for each strategy?
3. When were the solutions conceived?
 - a. What are the strategies that you had already developed before COVID-19?
 - b. What are the strategies that you developed “ex-novo” in order to face the COVID-19 effects on the SC?
 - c. What are the strategies that you are going to develop in the upcoming months (future) to further increase the SC resilience?
4. Starting from the strategies proposed in questions 1,2 and 3, highlight for how long they were/are going to be adopted:
 - a. Which are considered as permanent?
 - b. Which are considered as temporary?

Appendix B – pre-structured case outline (with some examples)

CASE	STRATEGY	CATEGORY	APPROACH		TIMING "WHEN"					TIMING "HOW LONG"				QUOTES
			Reactive	Proactive	CONCEPTION: PRE	CONCEPTION: DURING	ACTIVATION: PRE	ACTIVATION: DURING	ACTIVATION: POST	UTILISATION: PERMANENT	UTILISATION: TEMPORARY	AVAILABILITY: PERMANENT	AVAILABILITY: TEMPORARY	
RET 1	Streamline Logistics	Streamlining	X		X			X			X	X		
RET 1	Streamline Logistics	Streamlining		X	X			X			X	X		
RET 1	Switch of logistics flows	Dynamic Planning		X	X			X			X	X		
RET 1	Buffer Capacity	Redundancy	X			X		X			X		X	
RET 1	Batch Size	Decomplexity		X	X		X			X		X		
RET 1	Batch size	Decomplexity		X	X		X			X		X		
RET 1	SC analytics	Innovation		X	X		X			X		X		
RET 1	Collaborative planning	Collaboration	X		X			X			X	X		
RET 1	Buffer Capacity	Redundancy		X	X			X			X	X		
RET 1	Warehousing Automation	Innovation		X	X		X			X		X		
RET 1	Assortment review	Decomplexity	X			X		X			X		X	
RET 1	Assortment review	Decomplexity	X			X		X			X		X	
RET 1	Promotional activity	Decomplexity	X			X		X			X		X	
RET 1	Buffer Capacity	Redundancy	X			X		X			X		X	
RET 1	Switch of logistics flows	Dynamic Planning	X		X			X			X	X		
RET 1	Omni channel strategy	Innovation		X		X			X	X		X		
RET 1	Multiple sourcing	Redundancy	X			X			X	?		X		
RET 1	Information flow digitalisation	Collaboration		X	X		X			X		X		
RET 1	Order Management	Dynamic Planning	X			X		X			X		X	
RET 1	Buffer Capacity	Redundancy		X	X		X			X		X		Having an on-house inventory helped us to cope with the demand variations
RET 1	Switch of logistics flows	Dynamic Planning	X			X		X			X		X	
RET 1	Warehousing Automation	Innovation		X	X		X			X		X		

RET 1	Decision Making Process	Streamlining	X			X		X			X		X	
MAN 1	Decision Making Process	Streamlining		X	X			X			X	X		
MAN 1	Multiple sourcing	Redundancy		X	X			X			X	X		Having difficulties when sourcing from abroad, we will impose the balance between domestic and external suppliers
MAN 1	Plant fungibility	Fungibility		X	X			X			X	X		We took advantage of back-up logic within the production lines. Should one production line fail, another can be easily converted back.
MAN 1	Multiple sourcing	Redundancy		X	X			X			X	X		
MAN 1	Switch of logistics flows	Dynamic Planning	X		X			X			X	X		Depending on customer needs, we revised delivery logics: from customers' warehouses directly to their points of sale.
MAN 1	Batch Size	Decomplexity		X	X		X			X		X		
MAN 1	Batch size	Decomplexity	X		X			X			X	X		
MAN 1	Omni channel strategy	Innovation		X	X		X			X		X		
MAN 1	Transport Routing	Dynamic Planning	X		X		X			X		X		
MAN 1	Collaborative planning	Collaboration		X	X		X			X		X		It helped us increase visibility and better understand what was happening
MAN 1	Workforce fungibility	Fungibility		X	X			X			X	X		
MAN 1	Assortment review	Decomplexity	X			X		X			X		X	
MAN 1	Transport Routing	Dynamic Planning	X			X		X			X		X	
MAN 1	Financial Support	Collaboration	X			X		X			X		X	
MAN 1	Buffer Capacity	Redundancy		X		X			X		X	X		
MAN 1	Warehousing Automation	Innovation		X		X			X	X		X		
MAN 1	Switch of logistics flows	Dynamic Planning	X		X		X			X		X		
MAN 1	Information flow digitalisation	Collaboration		X		X			X	X		X		