Supply chain risk mitigation strategies: How the Covid-19 pandemic affected the watch industry and what can be improved for future disruptions?

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ABSTRACT

Purpose - The purpose of this paper is to give a clear (categorized) overview of supply chain risk mitigation strategies (SCRMS), discover how the watch industry was impacted by the Covid-19 pandemic and show what can be learned from or improved upon regarding the watch industry's approach to tackle supply chain disruption in the future.

Design/methodology/approach - After analysing relevant papers on the subject through an extensive systematic literature review, a multitude of unique SCRMS are extracted from the literature. Subsequently, this data is structured and organized in different risk clusters. Finally, data from practice is gathered through conducting a questionnaire. This questionnaire was sent out to 66 high-end horology companies. Through this questionnaire the impact of the Covid-19 pandemic on these supply chains (SC) and an insight into SCRMS that were utilized are analysed. Based on these analyses, a recommendation is given on what could be improved upon (in the supply chain) for future disruptions.

Findings - All extracted SCRMS from the literature are structured in 17 risk clusters to create an extensive and structured overview of various SCRMS. After that, the impact of Covid-19 on the watch industry is investigated through the means of a questionnaire, which resulted in identifying a significant demand rise within the watch industry. Yet this does not result in substantial supply chain disruption. Within the SCRMS adopted by the industry, a lack of information sharing and disruption identification could be identified and future recommendations are created.

Practical implications - SCRMS play a key role in a company's ability to be resilient and robust regardless of what disruption is experienced. Any company can significantly benefit from having SCRMS in place, in order to mitigate damage done by supply chain disruptions in any form.

Originality/value - This paper presents an extensive overview of available SCRMS in the current literature, categorized by risk clusters. Furthermore, this paper explores supply chain mitigation strategies within a rarely ever covered industry: the watch industry.

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Keywords

Supply chain, Risk management, Risk mitigation, Covid-19, Pandemic, Watch Industry, Artisan.

1. INTRODUCTION

Supply chain risk mitigation strategies (SCRMS) have always fulfilled an important role within enterprises in regards to risk management. But even though SCRMS can oftentimes be vital for the survival of an enterprise, developments in recent times have shown that there is still much to be improved upon. These recent years have been a true (and harsh) eye-opener for all organizations who previously have underestimated the far reaching consequences certain supply chain disruptions can have. The Covid-19 pandemic showed enterprises (on a global scale) that disruptions can happen unexpectedly and the consequences can be disastrous (snowballing, ripple, spill-over effects).

The social and economic losses caused by this pandemic are still, after two years of ongoing pandemic, accumulating and the end of it is still not in sight. As of May 2020, the global consumption losses caused by this disruption have amounted to 3.8 trillion dollars (USD), which caused wide-ranging indirect spill-over effects (nationally and internationally): job losses (equivalent to 147 million full-time employees) and income losses (equivalent to 2.1 trillion USD) [8]. International supply chains, with a heavy reliance on the most Covid-19 affected countries, have had it especially difficult in these times as their supply chains have been disrupted at their origin, which causes extensive ripple effects in the entire supply chain [8].

Considering what is at stake for enterprises: significant economic losses, forced downscaling or even bankruptcy, it is logical that supply chain risk management is one of the fastest growing areas in supply chain management research [7]. However, because the body of literature on this subject has been so rapidly growing in recent years, it becomes incredibly hard to keep track of what possible strategies there are to consider, especially when it is taken into account that risk mitigation does not have a "one size fits all" solution to it. Different industries react very differently to various disruption types at distinct times and therefore will need different mitigation strategies to combat the challenges they face. Therefore, in order to decide upon which SCRMS are effective to use, it is important to distinguish between: disruption cause, disrupted industry and disruption timing.

Disruption causes vary: is the disruption caused by man-made disaster or natural disaster? Or does the disruption originate from government policy changes, cyber security breaches within the

organization or caused by an epidemic or pandemic? Logically, these various causes require diverse approaches.

Different industries also can be faced with eminently contrasting disruption consequences. For example, the grocery industry during the Covid-19 pandemic has been faced with an significant increase in demand, which resulted in a negative supply shock caused by the panic-buying of consumers [19]. The airline industry, on the contrary, has been severely impacted by a decrease in demand. Clearly, depending on how an industry is impacted, different SCRMS should be used. For instance, during the Covid-19 pandemic, it has been found that the airline industry was best off by focusing their efforts as promptly as possible on the business continuity challenges the disruption caused. The automobile industry has had the most risk mitigating successes by developing localized sources and using advanced industry 4.0 technologies [11].

Furthermore, within these diverse disruption causes and industries, which come with numerous possible mitigation strategies, it is also useful to acknowledge the timing of the disruption. As, in order to enhance supply chain resilience, SCRMS can be implemented at three different points in time. According to Kamalahmadi and Parast [3], these are the following phases: 1. Anticipation **(**Proactive thoughts and plans), 2. Resistance (Maintain control over structures and functions) and 3. Recover & Response **(**Rapid and effective reactive actions). Phase 1 happens in pre-disruption, phase 2 during disruption and phase 3 after the disruption (post-disruption).

The quickly increasing body of literature on the subject of SCRMS brings two main issues forward: 1. Numerous strategies are explored, yet there is no clear overview of all possible options to choose from. 2. The numerous strategies found in the literature have no structure to them, which makes the process of choosing the right strategy for a certain problem within a supply chain difficult. In the systematic literature review of this paper these two problems are tackled: Firstly, an extensive literature review has led to the extraction of a variety of SCRMS, which are displayed in order to give an, as complete as possible, overview of all relevant strategies to consider. Secondly, in order to structure the vast amount of strategies, 17 categories are set up in which all the SCRMS of the literature review have been categorized to show the relevant strategies in clusters.

Subsequently, when examining the literature on supply chain disruptions it becomes clear that not all industries are represented in the same way. Industries that are covered a lot include (but are not limited to): the automotive industry, the airline industry and the healthcare industry. More niche industries are often not yet explored regarding this subject. In this paper, a contribution to the literature is done by exploring one of these, previously unexplored, niches: the high-end watch industry. The high-end watch industry makes an interesting case, as it differentiates on a lot of aspects compared to more common categories within the retail industry. In order to analyse how this industry has handled the Covid-19 pandemic, a questionnaire was sent out to 66 watchmaking companies.

Lastly, (based on the combination of strategies explored in the literature and the data from the questionnaire) suggestions are made on what the high-end watch industry could improve upon in the future to prepare for disruptions.

1.2 Definitions

This section presents the definitions of multiple regularly recurring expressions in order to be clear and transparent about what is meant by these terms in the context of this paper:

Supply chain resilience (SCR) as defined by Hosseini et al. (2019) [15]: "SC capability to utilize the absorptive capacity of SC entities to repulse and withstand the impacts of perturbations, to minimize the consequences of disruptions and their propagation by utilizing adaptive capacity and to recover performance level to normal operations in a cost-efficient manner using restorative capacity when absorptive and adaptive capacities are not sufficient."

Supply chain management (SCM): All managerial processes within an organization / enterprise, which serve the purpose of maximizing supply chain efficiency.

Supply chain risk mitigation strategies (SCRMS): All strategic approaches made for the purpose of mitigating/minimizing/avoiding supply chain disruption and all risks associated with it.

1.3 Research questions

The aim of this paper is to contribute to the literature on supply chain risk management. This is done by giving an extensive overview of currently explored SCRMS. Furthermore, in an effort to close the gap of knowledge within the literature in regards to supply chain risk management in the industry of watchmaking, a questionnaire is used to gather information on this subject. The following three research questions will be explored:

RQ1: How to mitigate supply chain disruption risks?

RQ2: How did the watch industry handle the supply chain disruptions caused by the Covid-19 pandemic?

RQ3: What could the watch industry improve upon in order to mitigate (additional) supply chain disruption risks?

2. SYSTEMATIC LITERATURE REVIEW

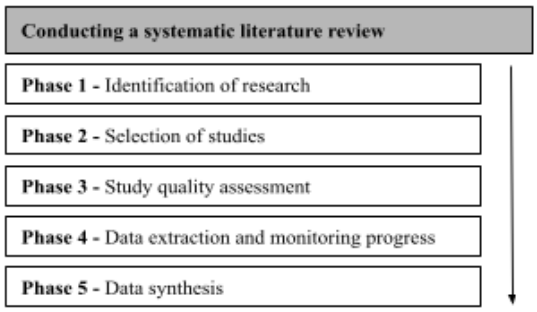
2.1 Methodology

The performed systematic literature review (SLR) for this research has been based on Denyer and Tranfield (2003) [22]. They define a clear set of guidelines on how to conduct a rigorous SLR without bias. Conducting an SLR can be organized in five consecutive phases [22] as can be seen in Figure 1.

Figure 1. Phases of conducting a systematic literature review (Source: Denyer and Tranfield, 2003)

2.1 Identification of research

In order to start the SLR a certain scope of keywords needed to



be defined. This was done in order to define the scale and scope of the review. These keywords are chosen based on the aforementioned research questions and are subsequently formed into queries which are used to find relevant articles in the SCOPUS citation database. After identifying fitting keywords, these first were analysed in an initial overview. Here the keywords were checked individually on how many articles the

search of the keyword yielded. Based on this the most relevant keywords were selected to be used in the queries. Various queries were set up to ensure all research areas of interest were covered. The following queries were created as a result:

1.((“supply chain”) AND (“risk management”))

2.((“supply chain”) AND ((“disruption”) OR ("ripple effect")))

These first two queries were set up in order to cover the basis of risk management and supply chain disruption literature.

3.((“supply chain”) AND (“risk management”) AND ((“covid-19”) OR (“pandemic”) OR (“SARS-CoV-2”) OR (“epidemic”) OR (“outbreak”)))

4.((“supply chain”) AND ((“covid-19”) OR (“pandemic”) OR (“SARS-CoV-2”) OR (“epidemic”) OR (“outbreak”)))"

5.((“supply chain”) AND (“ripple effect”) AND ((“covid-19”) OR (“pandemic”) OR (“SARS-CoV-2”) OR (“epidemic”) OR (“outbreak”)))

6.((“supply chain”) AND (“disruption”) AND ((“covid-19”) OR (“pandemic”) OR (“SARS-CoV-2”) OR (“epidemic”) OR (“outbreak”)))

The next four queries are aimed at capturing the relations between supply chain terminology such as risk management, ripple effect and disruption in combination with the Covid-19 pandemic. This is done in order to actively incorporate recent literature on the subject. There is a lot of overlap between these queries, as to be imagined considering they are very similar. This, however, does not pose any problems as all duplicates are removed in the literature evaluation process.

7.(("supply chain") AND (("artisan") OR ("traditional industry") OR ("handmade") OR ("craftsmanship") OR ("watch industry") OR ("watchmaking")))

The query above is constructed in order to find any literature which does combine information about supply chains in combination with watchmaking. But due to very limited results on purely the watchmaking industry, this query was extended to also include traditional industries and articles concerning artisans. As these terms are very much intertwined.

8.((“supply chain”) AND ((“covid-19”) OR (“pandemic”) OR (“SARS-CoV-2”) OR (“epidemic”) OR (“outbreak”)) AND ((“watch industry”) OR (“watchmaking”) OR (“artisan”) OR (“traditional industry”) OR (“handmade”) OR (“craftsmanship”)))

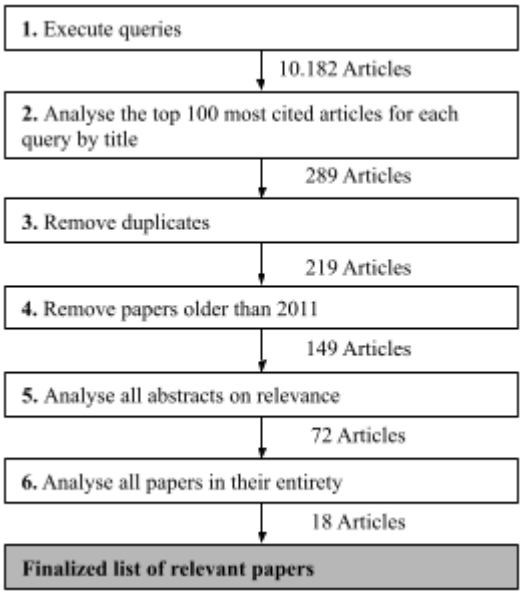
Lastly, an attempt is made to find literature combining not only the supply chain aspect with the Covid-19 factor, but also add the watchmaking element.

2.2 Selection of studies

After executing all queries in SCOPUS, they were subsequently exported and organized in a reference manager (EndNoteX9). The queries yielded a combination of 10.182 articles. This amount of articles of course far outreached the scale of this paper. So in order to make the base of the literature review manageable a six step procedure was performed (based on: Denyer and Tranfield, 2003). This process is also described in Figure 2.

Firstly, for each query the top 100 most cited articles were evaluated based on their title. Secondly, duplicates are removed. Thirdly, papers older than 2011 are removed. Fourthly, all 149 papers left at that stage were analysed based on the abstracts. And the final selection was made by reading through the entirety of the 72 papers kept after reading the abstract to ensure a good fit with this research. In the end, 18 papers qualified for further literature review. The complete list of these selected papers can be found in Appendix A.

Figure 2. Phases of conducting a systematic literature review (based on: Denyer and Tranfield, 2003)



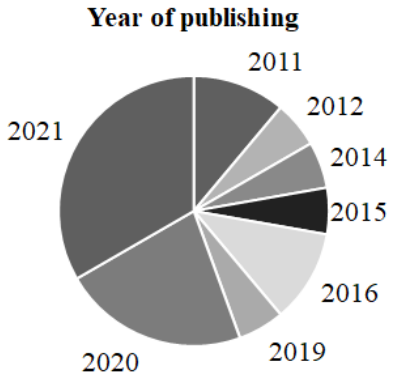
2.3 Descriptive analytics

The study quality assessment of the literature used in this paper is multifaceted. The quality assessment of this SLR is assessed/evaluated based on three criteria: publication year, source and fit between research methodology and research questions.

2.3.1 Publication year

As mentioned beforehand: papers older than 10 years were removed from the literature used for the SLR. This was done to ensure that the papers are up to par with the state of the art on this subject and are (currently) still relevant. The analysis of the eventually chosen papers show us the following (as also illustrated in Figure 3): 2021 (6 articles; 33%), 2020 (4 articles; 22%), 2019 (1 article; 6%), 2016 (2 articles; 11%), 2015 (1 article; 6%), 2014 (1 article; 6%), 2012 (1 article; 6%) and 2011 (2 articles; 11%).

Figure 3. Overview of publishing date dispersion



2.3.2 Source

In order to ensure the quality of the sources used and the originality of the literature, all paper sources were checked. No journal/conference has been used more than twice and the

average academic journal guide (AJG) ranking (of 2021) of all articles (for which an AJG ranking was available) is 2.69. The AJG is a guide which gives an indication of the quality of a journal based on a ranking system which assigns a score from 1 to 4+. The higher the score, the higher the quality of the journal is perceived. An average score of 2.69 indicates that on average the sources are well executed and original.

Figure 4. Overview of literature sources and their AJG ranking

Source	Articles	AJG (2021) Ranking
11th Annual International Conference on Industrial Engineering and Operations Management	1	Unknown
Computers and Industrial Engineering	1	2
Decision Sciences	1	3
IIE Transactions (Institute of Industrial Engineers)	1	3
International Journal of Logistics Management	1	1
International Journal of Operations and Production Management	1	4
International Journal of Physical Distribution & Logistics Management	2	Unknown
International Journal of Production Economics	2	3
International Journal of Production Research	1	3
Journal of Business Logistics	1	3
Journal of Business Research	1	3
Logforum	1	Unknown
Problems and Perspectives in Management	1	1
Supply Chain Management	1	3
Technological Forecasting and Social Change	1	3
Transportation Research Part E: Logistics and Transportation Review	1	3

2.4 Data extraction and monitoring progress

The goal of the data extraction process of this SLR was to collect and assemble an, as extensive as possible, listing of SCRMS from the literature.

This was achieved by reading all selected documents thoroughly and identifying risk mitigation strategies. During this process it promptly became apparent that there is no clear standardized terminology in this area of research, which made the process of extracting SCRMS from the papers more challenging. In order to move forward with the data extraction of all relevant strategies and tactics, the definition of SCRMS (which is mentioned in Section 1.2) was used as the standard for inclusion/exclusion. As long as the strategies found would match the SCRMS definition, it was qualified to be included in the list. The different variations of terminology used to indicate SCRMS have also been included in Appendix B, in order to show that this area of research could benefit from a standardized terminology. The complete overview of analysed papers and their contributions to the list of SCRMS can be found in Appendix B.

2.5 Data synthesis

According to Denyer and Tranfield (2003), data synthesis within the management research area should entail: “Higher levels of subjectivity associated with what is taken from an article for analysis and synthesis.” [22] In the data synthesis part of our SLR, this is done by putting the extracted data in a broader perspective through combining the strategies extracted from literature and structuring them in diverse risk clusters. Every risk cluster represents a distinctive group of SCRMS as they concern a different part of the supply chain.

This overview was created by an iterative process of categorization and went as follows: first, all SCRMS from the previous data extraction step were analysed and clusters of the same or closely related SCRMS were made. This clustering was expanded until all SCRMS were categorized in groups which had distinctive characteristics in common and could all be placed under a specific common category. Some SCRMS, however, fit the characteristics of more than one risk cluster, so there exist duplicate SCRMS in the risk cluster overview which create an overlap. This was done in order to make every cluster as complete as possible by itself, without having to refer to other clusters. In the second round, all clusters were analysed on the amount of strategies. The threshold for each cluster was set on having at least three SCRMS that fit the cluster and the cluster should have distinctive characteristics compared to other clusters. The SCRMS clusters with less than three strategies were re-evaluated to check if the SCRMS would possibly fit in another risk cluster. If not, they were added to the: Other strategies cluster. Lastly, an umbrella term for the strategies belonging to the risk cluster was created. The complete result of clusters including all analysed SCRMS can be found in Appendix C. The chosen risk clusters, number of SCRMS per cluster and all references to papers which had one or more SCRMS fitting the scope of the cluster can be found in Figure 5.

Figure 5. Overview of risk clusters of SCRMS and their respective literature references

Risk clusters	Amount of strategies	Mentioned/discussed in references
Sourcing	44	[1], [3], [4], [5], [6], [7], [11], [13], [14], [15], [16], [17], [19], [20], [21]
Relationships / Collaboration	25	[2], [3], [4], [6], [11], [12], [13], [14], [15], [16], [18], [19], [20], [21]
Inventory management	23	[1], [2], [3], [4], [5], [7], [11], [13], [14], [15], [16], [17], [19], [20]
Security	21	[1], [2], [3], [4], [11], [12], [16], [17], [20]
Forecasting / Simulations	21	[3], [4], [7], [11], [13], [20]
Information sharing	19	[1], [2], [3], [4], [7], [11], [12], [14], [15], [16], [20]
Flexibility	18	[1], [3], [13], [14], [15], [20], [21]
Responsiveness	15	[2], [3], [5], [6], [12], [15], [17], [20]
Capacity	13	[1], [3], [15], [17], [18], [19]
Product	13	[3], [7], [18], [19], [20]
Transportation	8	[2], [3], [5], [15], [16], [17], [20]
Visibility / Transparency	7	[2], [7], [12], [14], [15], [17], [21]
Training	6	[2], [3], [11], [16], [20]
Innovation	6	[3], [6], [11], [16]
Postponement	5	[3], [7], [18], [20], [21]
Location	3	[13], [19], [20]
Other strategies	42	[1], [2], [3], [6], [7], [11], [12], [13], [15], [16], [18], [19], [20], [21]

3. SLR FINDINGS AND INSIGHTS

Through this data synthesis 17 risk clusters have been created. A short description of each cluster will be provided next, and the most prevalent SCRMS for each cluster will be discussed.

3.1 Sourcing

Sourcing has been the risk cluster with the most related SCRMS to be found within the literature. This is not surprising, as sourcing does make up a very important part of supply chain management and therefore also comes with a lot of liabilities. The most common SCRMS in this category is by far multiple sourcing, which is mentioned in 11 papers [1, 3, 4, 5, 6, 7, 14, 15, 17, 20, 21]. The strategy has been addressed under various names with all the same meaning: in order to mitigate risks in your supply chain, make sure you have extra (backup) suppliers to source your materials/products from. Furthermore, SCRMS in this cluster focus on sourcing flexibility [6, 13, 14, 20, 21] and the regionalization of sourcing [3, 11, 14, 19].

3.2 Relationships / Collaboration

Relationships and collaboration play a key role in SCM and are applicable in regards to multiple groups: suppliers and customers, but also within the company itself: between functions. In the literature, there is mainly a focus on relationships and collaboration in regards to the upstream (supplier side) of the supply chain [2, 3, 4, 13, 14, 16, 18, 20].

3.3 Inventory management

Optimizing the level of inventory within the supply chain is crucial in order to provide if demands rise, but also in order to mitigate costs for holding inventory if demand decreases. The main focus in the literature is on inventory buffers in order to being able to provide products even if demands rise, or to ensure fulfilling demand if new inventory is hard to come by. This can be the case when the incoming flow of materials/products is not guaranteed (strategies that can help in this case are maintaining safety stock or a buffer) [2, 3, 4, 5, 11, 14, 16].

3.4 Security

Security is the antonym of risk, which logically makes it a very desirable element for SCM. But in order to obtain security, there are a lot of factors to consider and a lot of risks that need to be handled correctly. The most common approach to do this is by dispersing the risk. This can be done by risk pooling [4], risk and revenue sharing [12] and using risk-sharing contracts [20]. Insuring oneself against risks [16] also can be considered a form of risk dispersion. Yet not all strategies in this cluster require collaboration with other parties, such as risk monitoring [2], machine failure [20] and security system improvements [3].

3.5 Forecasting / Simulations

Another area to consider when looking to increase supply chain resilience is: forecasting / simulations. Modelling itself does not mitigate risk as is, but modelling can give various very useful and important insights which can be used for example to choose the right SCRMS for future scenarios. But modelling can also be used to identify current bottlenecks in the supply chain and its management, in order to mitigate current risks right away. Modelling can be focused on various factors within the supply chain such as inventory management, network flow, financial risks and can be conducted through various modelling approaches: continuous-review single-stage models, periodic-review single-stage models and multi-echelon models to name a few [20]. The most common focus for modelling within the literature of this research is forecast modelling [3, 4, 11, 20].

3.6 Information sharing

Information sharing has been instrumental in SCM and risk mitigation. Not only is it relevant in regards to communicating with for example customers [3, 7], it is also eminently important

in supply chain control. Because, active and effective sharing of information (for example transparency in stock levels, lead times, back orders and production problems) can warn suppliers and manufacturers of ongoing or incoming supply chain disruptions and give them the chance to act upon this information accordingly. This can be done through various ways, most prevalent in the literature were information sharing solutions using digital technologies to improve communication, this data sharing can be from and to various stakeholders in the supply chain, e.g. from and to suppliers, buyers, customers and within an organization between personnel [1, 3, 11, 12, 14, 16, 20].

3.7 Flexibility

Improving supply chain flexibility is mentioned often when discussing the subject of supply chain resilience. Increased supply chain flexibility increases the probability for a supply chain to withstand unforeseen supply chain disruptions. This can be done by holistic strategies to increase supply chain flexibility but also by being flexible concerning specific parts of the supply chain, for example in regards to maintaining a certain production capacity [1. 20], sourcing [3, 13, 14, 20, 21] and (switching between) transportation channels [3, 20].

3.8 Responsiveness

An agile supply chain is a supply chain which is able to respond (as quickly as possible) to any disruption. Responsiveness can mitigate disruption risks or if done very swiftly it can even prevent them. An example of supply chain agility is the ability to quickly redesign the supply chain itself [2, 5].

3.9 Capacity

The supply chain capacity is the ability of a supply chain to produce a certain volume of goods in a set period of time. Changing the capacity to match demands can be helpful in various situations, for example one can mitigate financial risks / consequences by downscaling capacity [17, 18]. It might also be needed to increase capacity at times, this can be done by implementing a certain amount of reserve capacity [1, 3, 15, 19].

3.10 Product

Not only the amount of products is important, as can be seen under inventory management, also the type of product and the product assortment can play an important role in supply chain resilience. A well-known SCRMS concerning products is (dynamic) assortment planning, [3, 7, 18, 19, 20] for example by prioritizing critical product categories or making changes in the product mix.

3.11 Visibility / Transparency

The higher the visibility within a supply chain the better / more precise materials, components, assemblies and products can be tracked. An accurate insight in the allocation of goods within the supply chain will be beneficial in order to improve supply chain resilience. So increasing visibility can serve as a good SCRMS [2, 7, 12, 14, 15, 17, 21].

3.12 Transportation

Transportation is important in various parts of the supply chain. Not only is it important from supplier to manufacturer, but it can be equally important to transport items from the manufacturer to consumers. The main strategy to mitigate risks associated with transportation is setting up alternative transportation channels to fall back on in case of disruption [2, 15, 16, 17] this can be done for example through port diversification plans [2]. This cluster has a significant overlap with the flexibility cluster but was deemed important enough to be ordered and mentioned separately as well.

3.13 Training

Previous risk clusters are often associated with systems, facilities and goods. But company staff also can play a significant role in supply chain management. According to the literature training can help improve staff capabilities by educating them on various risk management subjects [2. 3. 11. 16. 20].

3.14 Innovation

Innovation can stimulate supply chain risk management through various forms of technology deployment, [3, 6, 11] with more specific examples being the implementation of virtual marketplaces and supply chain automation [11].

3.15 Postponement

Postponement is the only SCRMS for which the literature agree on the same terminology. Postponement could have been categorized under the risk cluster products, but as it is not only product/production related but also can impact transport and it is so well represented on its own in the literature, it was decided to give it its own individual risk cluster in order to emphasize its importance. Postponement is the act of purposely delaying final steps in the manufacturing process, and to modify the generically produced products later on. Postponement can also mean deliberately postponing the transportation of products [3, 7, 18, 20, 21].

3.16 Location

Selecting the right location for a facility can influence the supply chain not only in regards to optimizing transportation between the enterprise and its suppliers and customers [13. 19], but it is also an important criteria to consider in regards to safety [20] (for example when considering the risk on natural disasters but also political instability).

3.17 Other strategies

Lastly, after setting up various risk clusters we are still left with a diverse selection of other SCRMS within the literature that could be beneficial for various situations / enterprises. These include, but are not limited to: increasing supply chain sustainability [6, 12] and hedging [3, 20].

4. QUESTIONNAIRE

In order to answer research question two, an investigation into how the watch industry handled the Covid-19 pandemic (up until November 2021) was set up in the form of a questionnaire. This questionnaire was created with the guidelines set out by Kelley et al. [23] in mind.

4.1 Methodology

The research into RQ2 was conducted through, what Kelley et al. [23] define as a postal questionnaire. This research method is a form of descriptive research. Data collection was done through the online platform Google Forms. All data collection was done completely anonymously.

The questionnaire was structured into four sections. In section 1 of the questionnaire basic questions on the characteristics of the participant and the company were posed. In section 2 questions were asked in order to identify in what way, when and to what extent the company had to deal with disruptions in its supply chain caused by the Covid-19 pandemic. Section 3 continues with the same goal as section 2, it, however, poses only questions on a scale basis. Lastly, in section 4, the participant is questioned

about what SCRMS are in place at his/her company, what the company has learned from this disruption and finally if they are planning on implementing changes to respond to future disruptions.

4.2 Data collection inclusion and exclusion criteria

The questionnaire was sent out to 66 different companies. These companies were chosen based on a number of inclusion and exclusion criteria. First of all, in order to be eligible for this research, the company had to specialize in high-end watchmaking, or better known in the industry as haute horlogerie. Both of these terms, however, are not clearly defined and are debated a lot. That is why the choice was made to only invite watchmaking companies which sell their (new and male) watch models at no lower than a 2,000 EUR price point. Brands which do not solely focus on watchmaking but also produce other jewellery were also included. Companies which also focus on luxury textile products were, however, excluded from this research.

The age, heritage, country of origin, amount of employees, production numbers and ability to fully produce in-house movements are all factors that were not used in the in-/exclusion process.

4.2 Descriptive analytics

The questionnaire was eventually filled out by 7 out of the 66 contacted companies, which sets the response rate at 10.5%. Up next, important analytics taken from these results will be presented to sketch an, as complete as possible, picture of the industry in these turbulent times. Afterwards, these analytics will be interpreted in the research findings.

4.2.1 Section 1: Baseline questions

When analysing the results of section 1 a few statistics instantly stand out. First of all, the location. All of the responding participants are Swiss based. This, however, is not surprising as Switzerland is known for its luxury watch industry and most contacted companies were based in Switzerland. Secondly, we see that the company size is not exceeding the 50 to 250 employee mark. With most companies being even smaller, having 10 to 50 employees. The job descriptions of the respondents vary heavily: from CEO/owner/founder to sales assistant. Also, the number of suppliers used in the manufacturing process as well as the amount of timepieces produced vary significantly between companies, whereas the location of these suppliers did vary at all. All suppliers mentioned were based in Europe. However, it should be noted that limited data is available on the production numbers as multiple participants did not want to disclose this information.

4.2.2 Section 2: Supply chain disruptions due to the Covid-19 pandemic

Section 2 gave insights into how the companies were impacted by the Covid-19 pandemic and what measures were implemented to counteract possible risks. Out of the 7 participants 4 mentioned risk mitigation strategies that were in place before the Covid-19 pandemic hit. These strategies were the prepositioning of inventory, producing everything in house, locally sourcing suppliers and, where possible, setting up backup suppliers. When asked about what countermeasures were taken during the Covid-19 pandemic 3 out of 7 participants gave a countermeasure they used to combat supply chain disruption: allocating all manufacturing aspects to Switzerland (backshoring), setting up more couriers and the lastly: “Work harder and faster, turn myself into a driver and delivery guy”. No clear SCRMS from the literature can be matched to this answer.

The average of how severe the supply chain was disrupted by the Covid-19 pandemic was set at 3.86, ranging from 1 (very severe) to 5 (barely noticeable). Most participants (4/7) experienced it as barely noticeable, while only one experienced it as very severe. This participant added to this that most middle-sized companies were “shot down” as a result of the Covid-19 pandemic. As also seen in other industries, it was noted that the watchmaking industry benefitted from e-commerce a lot..

On average the rise/drop of demand was evaluated at an average score of 3.57, ranging from 1 (dropped significantly) to 5 (increased significantly). Production did stop for 3/7 respondents, varying from a few days up to a month. The moment in which the supply chain disruption was identified varies significantly from March 2019, March 2020, March 2021 and one participant notes it was not disrupted at any point in time. However, all answers in regards to how this disruption was detected are unanimously pointing towards human awareness.

4.2.3 Section 3: The impact of the disruption on the supply chain

In section 3 of the questionnaire individual factors are evaluated, in order to investigate which factors were disrupted the most. All questions are based on a Likert scale ranging from 1 (no impact) to 5 (significant impact) . The following scores are all calculated averages. An increase in demand: 4.33; A decrease in demand: 2.4; Restrictions due to having to comply with coronavirus safety precautions: 2.71; Extended lead times from suppliers: 3; Market uncertainty: 2.57; Entire production stops: 1.71; The suppliers abilities to deliver (enough) materials: 2.43.

4.2.4 Section 4: Reflecting on supply chain risk management and future developments

Section 4 is the last section of the questionnaire. This section focuses on reflecting on supply chain risk management as well as posing questions about future approaches. The results of this section show that only 1 out of 7 (14.3%) companies have specialized staff in regards to supply chain management, that less than half (3 out of 7; 42.9%) of the participating companies exchange information with other supply chain partners on a regular basis. When asked what type of information is exchanged participant 6 adds that they have regular meetings to cover all elements: in particular lead times, workload and delivery delays. When asked in what way one gets access to this information: participant 2 answers by e-mail, participant 4 says through their internal system or also by e-mail and lastly participant 6 adds through verbal communication or by means of physical one2one meetings. Lastly, participants are asked what they learned from this disruption and what changes they will implement in the future, here various insights are given: keeping it simple, fabricating products by only buying rough materials, being independent and being Swiss made are important factors. Furthermore, double sourcing and top-notch information systems are needed in the future. Multiple participants, however, also indicate they will not be changing anything in the future.

5. RESEARCH FINDINGS

5.1 How was the watch industry impacted by the Covid-19 pandemic?

Based on the information gathered through the questionnaire, it can be concluded that the watch industry was mainly impacted by the Covid-19 pandemic through a significant demand

increase. However, according to the questionnaire, this did not result in much supply chain disruption.

This perhaps can be explained by the sourcing of materials as all respondents indicated that most of the materials used in the manufacturing process were sourced from within Europe. According to Guan et al. (2020) [8] the pandemic most directly impacted businesses which are deeply reliant on suppliers in countries which were affected most severely by the Covid-19 pandemic.

Furthermore, another explanation for the lack of disruption caused by the significant rise in demand is: exclusivity. A very important aspect of buying luxury goods, and this also perfectly translates into high-end watchmaking, is exclusivity. The scarcity associated with exclusivity allows the product to maintain its prestige. The level of exclusivity is maintained by limiting production runs. Some of the participants stated that they produce less than 100, or only roughly 200 or 300 timepieces a year. There are also some companies who produce more (18,000 and 100,000 timepieces a year). Yet compared to the size of the high-end timepiece market these numbers are still not as large as one might expect.

If a company deliberately were to produce a limited amount of timepieces, in order to maintain a certain level of exclusivity, then this level of production would need to be constant. Therefore, a rise in demand would not impact nor disrupt the supply chain as the company would not react to this change in demand.

5.2 Current state of supply chain risk management

This research has shown that the current state of supply chain risk management within the watch industry is fairly limited. 4 out of 7 participants indicated that they have had some sort of SCRMS in place before the pandemic and 3 out of 7 participants expanded their supply chain with one countermeasure during the Covid-19 pandemic. The strategies are mostly based around sourcing, with a clear majority being focussed on manufacturing and sourcing exclusively in Switzerland.

5.3 Future recommendations

It can be concluded that the watch industry performed very well during the Covid-19 pandemic, as demand was up and little supply chain disruption was experienced overall. However, just because this time around the consequences are not as severe, does not mean they are safe from future disruptions. For example, if disruption would be most prevalent in Switzerland, what course of action should be taken then. These are important questions to ask oneself and prepare for, as these questions can be vital in order to survive in times of severe disruptions. It is important to be agile, and (re)act quickly and correctly when a disruption is discovered. However, being prepared and resilient is even better.

Therefore, it is recommended to consider implementing more SCRMS. Two weak points stood out during the analysis in this regard: 1. Disruption detection and 2. Information sharing. All participants pointed out that disruption was discovered through human awareness. Monitoring supply chain processes automatically by digitally implemented process monitoring can possibly remedy this situation. Furthermore, an increased level of information sharing also can help detect disruption early on.

4 out of 7 participants answered that they exchange no information at all on a regular basis with other supply chain partners. While improved information sharing can help significantly with mitigating supply chain risks , it can moreover form a valuable asset in operational supply chain management.

Additionally, it is recommended to explore other SCRMS as well. The overview given in this paper can serve as a guide in this process. In order to find the best and most cost efficient SCRMS, it is recommended to use some form of modelling to create insights in this matter.

6. CONCLUSION

Supply chain risk management is an immensely important area within every business. These recent turbulent times, caused by the Covid-19 pandemic, prove this once more. In this paper we attempt to bring some structure to this rapidly expanding research area in the form of an overview of SCRMS. Although, the overview does not captured all possible SCRMS, it does cover a significant amount. And through categorizing them into risk clusters, a structured overview is given of possible strategies to mitigate supply chain disruption risk (RQ1).

The watch industry was faced with a significant demand increase as a consequence of the Covid-19 pandemic. However, this did not result in serious supply chain disruption within the industry. (RQ2)

Lastly, recommendations are made for the watch industry to mitigate (additional) supply chain disruption risks. These recommendations are threefold: improve upon disruption detection, information sharing and conduct a cost-benefit-analysis through modelling to explore which extra SCRMS can help in future disruptions.

6.1 Limitations

This research comes with a number of limitations. First and foremost, it needs to be acknowledged that all research findings expressed based upon the results of the questionnaire, are based on a relatively small data set. The high-end watch industry is only a small niche within the overarching retail industry. A very extensive research has gone into setting up a database with as many high-end watchmaking firms as possible. Yet, when taking all inclusion and exclusion criteria in mind, it still only left 66 firms to contact. Secondly, the entirety of this research was limited to a time period of 10 weeks. This resulted in having only 2 weeks to conduct the questionnaire. This had a limiting impact on the amount of data gathered, as some firms were not able to answer in time. Additionally, this also holds true concerning the amount of literature that could be analysed in the SLR.

6.2 Future work

The future work recommendations which result from this research are multifold: First, an even more extensive overview of the literature can and should be made in order to create an all encompassing list of SCRMS. Secondly, in order to improve the correct and most beneficial implementation of SCRMS; the list would benefit from additionally giving insight into the cost and possible reward of implementing certain strategies. Thirdly, the area of SCRMS still has a lot of potential for new strategies. For example, by exploring the possible applications of artificial intelligence (AI) and big data management within the context of SCM new and more effective forms of information exchange and interpretation can possibly be facilitated. Lastly, the watch industry niche is still a severely undiscovered area of research. The industry could, however, benefit from more academic exposure in the future.

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APPENDIX

Appendix A: List of all papers used for the SLR

Ref. no.	Title of the Article
[1]	Achieving supply chain efficiency and resilience by using multi-level commons.
[2]	An empirically derived framework of global supply resiliency.
[3]	A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research.
[4]	Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP).
[5]	Costs of resilience and disruptions in supply chain network design models: A review and future research directions.
6]	Covid-19′s impact on supply chain decisions: Strategic insights from NASDAQ 100 firms using Twitter data.
[7]	Dealing with supply chain risks: Linking risk management practices and strategies to performance.
[11]	Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries.
[12]	Measuring supply chain resilience using a deterministic modeling approach.
[13]	OR/MS models for supply chain disruptions: A review.
[14]	Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice.
[15]	Review of quantitative methods for supply chain resilience analysis.
[16]	Smart „plan b" – in face with disruption of supply chains in 2020.
[17]	Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors.
[18]	Supply chain disruptions in the context of early stages of the global COVID-19 outbreak.
[19]	Supply chain risk management strategies in the face of COVID-19.
[20]	Supply chain risk management: A literature review.
[21]	Supply chain risk mitigation strategies during COVID-19: exploratory cases of "make-to-order" handloom saree apparel industries.

Appendix B: All extracted strategies from papers included in the SLR

Ref. no.	Author	Expression used:	Strategies:
[1]	Chopra, S., Sodhi, M., & Lücker, F. (2021)	Strategies for resilience	Tailored sourcing; Omni-channel retail; Investing in flexible capacity and its use through better information; Investing in caution; Investing in risk mitigation inventory (RMI); Investing in reserve capacity;
[2]	Blackhurst, J., Dunn, K. S., & Craighead, C. W. (2011)	Supply resiliency enhancers	Education and training of employees to execute supply chain contingency plans; Employee's understanding of cost⁄benefit trade-offs when managing risk in a supply chain; Ability to perform post disruption analysis;Defined communication protocols; Cross-functional supply chain risk management teams; Predefined and⁄or self-executing contingency plans; Partnering with customs programs (such as C-TPAT); Developing port diversification plans; Developing supplier relationship management programs; Use of safety stock; Increased visibility in the supply chain; Exception reporting systems; Predictive tools for early awareness of impending disruptions; Risk monitoring systems for each node (i.e., firm) in the supply chain; Ability to quickly redesign the supply chain;
[3]	Kamalahmadi, M., & Parast, M. M. (2016)	Supply chain resilience strategies	Add capacity; Add inventory; Redundant suppliers; Increase responsiveness; Increase flexibility; Aggregate or pool demand; Increase capabilities; Have more customer accounts; Postponement; Strategic stock; Flexible supply base; Make and buy; Economic supply incentives; Flexible transportation; Revenue management; Dynamic assortment planning; Silent product rollover; Operational mitigation: Strategies based on suppliers and inventory prior to disruption; Operational contingency: Strategies based on flexibility after disruption; Speculation; Hedging; Control / Share / Transfer; Avoidance; Indirect investment; Discovery; Information; Supply chain design; Buffers; Operational flexibility; Preparedness; Segmenting or Regionalizing supply chains; Avoiding too much centralization of resources; Overinvesting in protection; Back-up capacity; Building relation with buyers and suppliers; Quality control; Skill and efficiency development; ICT adoption; Demand forecasting; Responsiveness to customers; Security system improvement;
[4]	Tummala, R., & Schoenherr, T. (2011)	Risk mitigation plans / Risk response action plans	Buffer inventories; Information technologies; Effective relationships with suppliers; Effective relationships with downstream customers; Involvement of alternative or multiple suppliers; Risk pooling; The conduct of "what if" analysis;
[5]	Aldrighetti, R., Battini, D., Ivanov, D., & Zennaro, I. (2021)	Mitigation strategies	Backup supply; Reliable backup assignment; Transshipment; Operational reassignment;
[6]	Sharma, A., Adhikary, A., & Borah, S. B. (2020)	Strategic recommendations	Focus on sustainable supply chain; A dire need of a dynamic response; Derive values from technology deployment; Develop a culture of collaboration; Diversify supply chain; Synchronize strategic processes;
[7]	Wieland, A., & Marcus Wallenburg, C. (2012)	Agile and robust measures	Multiple sources of supply; Inventory; Make-and-buy; Product design; Logistical network design; Supplier/buyer communication; Business continuity planning; Visibility; Assortment planning; Make-to-order; Postponement;

[11]	Belhadi, A., Kamble, S., Jabbour, C. J. C., Gunasekaran, A., Ndubisi, N. O., & Venkatesh, M. (2021)	Supply chain risk mitigation strategies	Digital connectivity; Supply chain automation; Localization/regionalization of sourcing; Integrated supply chain risk management; Social supply chain focus; Human capabilities; Lifeline maintenance; BDA-driven and real-time information system; Virtual marketplaces; Supply chain simulation; Supply chain collaboration; Inventories and reserve capacity; Business continuity plans; Decision-making proximity;
[12]	Soni, U., Jain, V., & Kumar, S. (2014)	Supply chain resilience enablers	Agility; Collaboration; Information sharing; Sustainability; Risk and revenue sharing; Trust (among players); Visibility; Risk management culture; Adaptive capability; Supply chain structure;
[13]	Snyder, L. V., Atan, Z., Peng, P., Rong, Y., Schmitt, A. J., & Sinsoysal, B. (2016)	Mitigation strategies	Inventory management (this can be done by various modelling solutions: Continuous-review single-stage models, Periodic-review single-stage models, Multi-echelon models); Sourcing flexibility (through routine sourcing and contingent rerouting); Demand flexibility; Facility location (through basic modelling; interdiction, location and fortification; location-inventory modelling); Interaction with external partners (through contracts to induce truth-telling; contacts and incentives to improve reliability and restore capacity; competition; contracts for reimbursement of the loss); Strategic selection of mitigation strategy;
[14]	Remko, V. H. (2020)	Suggestions for improving supply chain resilience	Avoid overreliance on single/few factories for supplies; Ensure multiple, flexible and alternative sources; Include near and local sourcing in the supply chain; Inventory buffering; Active information sharing throughout the supply chain; Use information technology to improve visibility into demand and transparency of inventory; Focus on ensuring supply with bottleneck suppliers, ensure collaboration with strategic suppliers; Negotiate savings with selected suppliers only;
[15]	Hosseini, S., Ivanov, D., & Dolgui, A. (2019)	Conceptual drivers of supply chain resilience / Absorptive capacity / Adaptive capacity	Agility; Robustness; Visibility; Flexibility; Collaboration; Information sharing; Supplier segregation; Multiple sourcing strategy; Inventory positioning; Multiple transportation channels; Backup supplier; Rerouting; Communication; Substitution; Restorative capacity;
[16]	Marzantowicz, Ł., Nowicka, K., & Jedliński, M. (2020)	Supply chain resistance to disruption	Training staff for supply chain risk management; Predefined action plan for alternative scenarios in the event of emerging threats; Changing the supply chain management strategy to a hermetic one (closed loop); Renegotiate trade agreements (for joint responses in the future); Change supply policy and inventory management (maintain higher inventory levels); Take security measures (consider own transport/storage facilities); Shortening the supply chain (by developing cooperation with local suppliers); Digital technologies (concerning information exchange, supply chain reconfiguration and analysis of the economic environment); Insurance (against humanitarian threats);
[17]	Butt, A. S. (2021)	Countermeasures	Agile manufacturing; Enhanced inbound material visibility; Focus on tier 1 supplier risk; Closing production facilities; Modification in inventory policies; Evaluating alternative logistics options; Evaluating alternate sources of supply;
[18]	Veselovská, L. (2020)	(Initial) Response measures	Changes in product mix; Changes in operating volumes; New marketing promotion; Downsizing; Recruiting; Cost reduction; New supply chain partnership development; Payments renegotiations and postponements; New discounts introduction;

[19]	Woong, J. Y., & Goh, S. H. (2021)	Supply chain resilience strategies / Supply chain risk mitigation strategies	Offline-to-Online; Product Portfolio Mix; Strategic Facility Placement; Stock Control; Increasing Capacity; Diversifying Single-Product Categories; Local Sourcing; Prioritising Critical Categories; Repurposing Assets; Establishing partnerships; Leveraging Social Media Influence;
[20]	Ho, W., Zheng, T., Yildiz, H., & Talluri, S. (2015)	Risk mitigation methods	Secure location selection; Postponement, Strategic stock, Flexible supply base; Make-and-buy; Economic supply incentives; Flexible incentives; Flexible transportation; Revenue management; Dynamic assortment planning; Silent product rollover; Automatic pipeline inventory; Order-based production control system algorithm; Risk-sharing contracts to minimise the loss of manufacturer and the loss of retailers under demand uncertainty or weather-sensitive demand; Bilateral contracts with order quantity flexibility; Optimise expected profits by quoting a uniform guaranteed maximum lead time to all customers under demand uncertainty; Dynamic system model of manufacturing supply chains; Multiperiod deterministic linear programming to generate a robust logistics plan; Quality risk; Lead time uncertainty; Random yield risk; Non-conforming product design; Capacity inflexibility; Machine failure; Building strategic supplier relationships; Early supplier involvement; Adopting business continuity plannings as a formal risk management technique; Reducing supply base complexity; Determination of the optimal inventory level or policies; Investigation of how managers mitigate global sourcing risks; Risk and quality control of a supplier; Allocation of supplier development investments among multiple suppliers; Analysis of the impact of strategic information acquisition and sharing on supply risk mitigation; Examination of the effectiveness of hybrid push-pull strategy for supply risk mitigation; Exploration of actions to proactively mitigate supplier insolvency risk; Determining the optimal production and ordering quantities (for supplier and retailer), as well as duration for recovery subject to transportation disruption, which yields the minimum relevant cost of the system; Natural hedging of currency and commodity price fluctuations; Nonlinear programming modelling to optimize cash supply chains; Network flow modelling to mitigate the financial risks in the cash supply chain; Construction of attribute correspondence matrices for databases; Minimizing data sharing risks by an association rule hiding algorithm; Increase flexibility; Building collaborative relationships among supply chain members; Information sharing in the supply chain; Managing suppliers; Adopting co-opetition; Increasing agility; Implementing corporate social responsibility activities; Understanding diverse organisation cultures; Applying a new pull system called the multi Kanban system for disassembly; Network modelling to integrate global supply chain networks with social networks; Supply Chain Risk Structure Model; The Supply Chain Risk Dynamics Model; House of risk that combines the QFD and FMEA; Two-stage stochastic integer programming modelling;
[21]	Dohale, V., Ambilkar, P., Gunasekaran, A., Verma, P., (2021)	Risk mitigation strategies	Visibility and transparency; Flexibility; Relationships / partnerships; Postponement; Multiple sourcing; Flexible sourcing contracts; Redundancy; Collaboration; Joint planning and coordination;

Appendix C:All supply chain risk mitigation strategies ordered by risk cluster

Overarching strategy	Ref. No.
Sourcing	[1] Tailored sourcing; [3] Redundant suppliers; Flexible supply base; Economic supply incentives; Strategies based on suppliers and inventory prior to disruption; Avoiding too much centralization of resources; Segmenting or Regionalizing supply chains; [4] Effective relationships with suppliers; Involvement of alternative or multiple suppliers; [5] Reliable backup assignment; [6] Diversify supply chain; [7] Multiple sources of supply; [11] Localization/regionalization of sourcing; [13] Sourcing flexibility (through routine sourcing and contingent rerouting); [14] Focus on ensuring supply with bottleneck suppliers, ensure collaboration with strategic suppliers; Negotiate savings with selected suppliers only; Ensure multiple, flexible and alternative sources; Avoid overreliance on single/few factories for supplies; Include near and local sourcing in the supply chain; [15] Supplier segregation; Backup supplier; Multiple sourcing strategy; Rerouting; Substitution; [16] Shortening the supply chain (by developing cooperation with local suppliers); [17] Focus on tier 1 supplier risk; Evaluating alternate sources of supply; Evaluating alternative logistics options; [19] Local Sourcing; [20] Early supplier involvement; Building strategic supplier relationships; Managing suppliers; Allocation of supplier development investments among multiple suppliers; Exploration of actions to proactively mitigate supplier insolvency risk; Risk and quality control of a supplier; Flexible supply base; Investigation of how managers mitigate global sourcing risks; Reducing supply base complexity; Managing suppliers; Random yield risk; Lead time uncertainty; Bilateral contracts with order quantity flexibility; [21] Multiple sourcing; Flexible sourcing contracts;
Relationships / Collaboration	[2] Partnering with customs programs (such as C-TPAT); Developing supplier relationship management programs; Cross-functional supply chain risk management teams; [3] Building relation with buyers and suppliers; [4] Effective relationships with suppliers; Effective relationships with downstream customers; [6] Develop a culture of collaboration; [11] Supply chain collaboration; [12] Collaboration; Trust (among players); [13] Interaction with external partners (through contracts to induce truth-telling; contacts and incentives to improve reliability and restore capacity; competition; contracts for reimbursement of the loss); [14] Focus on ensuring supply with bottleneck suppliers, ensure collaboration with strategic suppliers; [15] Collaboration; [16] Renegotiate trade agreements (for joint responses in the future); [18] New supply chain partnership development; [19] Establishing partnerships; [20] Building strategic supplier relationships; Building collaborative relationships among supply chain members; Adopting co-opetition; [21] Relationships / partnerships; Collaboration; Joint planning and coordination;

Inventory management	[1] Investing in risk mitigation inventory (RMI); [2] Use of safety stock; [3] Add inventory; Strategic stock; Buffers; Strategies based on suppliers and inventory prior to disruption; [4] Buffer inventories; [5] Backup supply; [7] Inventory; [11] Inventories and reserve capacity; [13] Inventory management (this can be done by various modelling solutions: Continuous-review single-stage models, Periodic-review single-stage models, Multi-echelon models); [14] Focus on ensuring supply with bottleneck suppliers, ensure collaboration with strategic suppliers; Inventory buffering; [15] Inventory positioning; [16] Change supply policy and inventory management (maintain higher inventory levels); [17] Modification in inventory policies; Evaluating alternative logistics options; [19] Stock Control; [20] Automatic pipeline inventory; Strategic stock; Economic supply incentives;
Security	[1] Investing in caution; [2] Risk monitoring systems for each node (i.e., firm) in the supply chain; Predictive tools for early awareness of impending disruptions; [3] Security system improvement; Overinvesting in protection; Preparedness; [4] Risk pooling; [11] Integrated supply chain risk management; [12] Risk and revenue sharing; Risk management culture; [16] Take security measures (consider own transport/storage facilities); Insurance (against humanitarian threats); [17] Focus on tier 1 supplier risk; [20] Risk-sharing contracts to minimise the loss of manufacturer and the loss of retailers under demand uncertainty or weather-sensitive demand; Minimizing data sharing risks by an association rule hiding algorithm; Investigation of how managers mitigate global sourcing risks; Exploration of actions to proactively mitigate supplier insolvency risk; Risk and quality control of a supplier; Machine failure; Lead time uncertainty; Optimise expected profits by quoting a uniform guaranteed maximum lead time to all customers under demand uncertainty;
Modelling	[3] Demand forecasting; Speculation; Supply chain design; [4] The conduct of “what if” analysis; [7] Logistical network design; [11] Supply chain simulation; [13] Inventory management (this can be done by various modelling solutions: Continuous-review single-stage models, Periodic-review single-stage models, Multi-echelon models); Facility location (through basic modelling; interdiction, location and fortification; location-inventory modelling); [20] Supply Chain Risk Structure Model; The Supply Chain Risk Dynamics Model; Network flow modelling to mitigate the financial risks in the cash supply chain; Dynamic system model of manufacturing supply chains; Nonlinear programming modelling to optimize cash supply chains; Two-stage stochastic integer programming modelling; Network modelling to integrate global supply chain networks with social networks; Determining the optimal production and ordering quantities (for supplier and retailer), as well as duration for recovery subject to transportation disruption, which yields the minimum relevant cost of the system; Determination of the optimal inventory level or policies; Multiperiod deterministic linear programming to generate a robust logistics plan; House of risk that combines the QFD and FMEA;

Information sharing	[1] Investing in flexible capacity and its use through better information; [2] Defined communication protocols; Exception reporting systems; [3] Responsiveness to customers; ICT adoption; Information; Control / Share / Transfer; [4] Information technologies; [7] Supplier/buyer communication; [11] Digital connectivity; BDA-driven and real-time information system; [12] Information sharing; [14] Use information technology to improve visibility into demand and transparency of inventory; Active information sharing throughout the supply chain; [15] Information sharing; Communication; [16] Digital technologies (concerning information exchange, supply chain reconfiguration and analysis of the economic environment); [20] Minimizing data sharing risks by an association rule hiding algorithm; Information sharing in the supply chain;
Flexibility	[1] Investing in flexible capacity and its use through better information; [3] Increase flexibility; Flexible supply base; Strategies based on flexibility after disruption; Flexible transportation; Operational flexibility; [13] Sourcing flexibility (through routine sourcing and contingent rerouting); Demand flexibility; [14] Ensure multiple, flexible and alternative sources; [15] Flexibility; [20] Flexible supply base; Flexible incentives; Flexible transportation; Increase flexibility; Bilateral contracts with order quantity flexibility; Capacity inflexibility; [21] Flexibility; Flexible sourcing contracts;
Agility	[2] Ability to quickly redesign the supply chain; [3] Increase responsiveness; [5] Operational reassignment; [6] A dire need of a dynamic response; [12] Agility; Adaptive capability; [15] Agility; [17] Agile manufacturing; [20] Increasing agility;
Capacity	[1] Investing in flexible capacity and its use through better information; Investing in reserve capacity; [3] Add capacity; Increase capabilities; Back-up capacity; [15] Restorative capacity; [17] Closing production facilities; [18] Changes in operating volumes; Downsizing; Recruiting; Cost reduction; [19] Increasing Capacity; Capacity inflexibility;

Product	[3] Dynamic assortment planning; Quality control; Silent product rollover; [7] Product design; Assortment planning; [18] Changes in product mix; [19] Product Portfolio Mix; Diversifying Single-Product Categories; Prioritising Critical Categories; [20] Dynamic assortment planning; Quality risk; Non-conforming product design; Silent product rollover;
Transportation	[2] Developing port diversification plans; [3] Flexible transportation; [5] Transshipment; [15] Multiple transportation channels; [16] Take security measures (consider own transport/storage facilities); [17] Evaluating alternative logistics options; [20] Flexible transportation; Determining the optimal production and ordering quantities (for supplier and retailer), as well as duration for recovery subject to transportation disruption, which yields the minimum relevant cost of the system;
Visibility	[2] Increased visibility in the supply chain; [7] Visibility; [12] Visibility; [14] Use information technology to improve visibility into demand and transparency of inventory; [15] Visibility; [17] Enhanced inbound material visibility; [21] Visibility and transparency;
Training	[2] Education and training of employees to execute supply chain contingency plans; Employee's understanding of cost⁄benefit trade-offs when managing risk in a supply chain; [3] Skill and efficiency development; [11] Human capabilities; [16] Training staff for supply chain risk management; [20] Implementing corporate social responsibility activities;
Innovation	[3] ICT adoption; Discovery; [6] Derive values from technology deployment; [11] Virtual marketplaces; Supply chain automation; [16] Digital technologies (concerning information exchange, supply chain reconfiguration and analysis of the economic environment);
Postponement	[3] Postponement; [7] Postponement; [18] Payments renegotiations and postponements; [20] Postponement; [21] Postponement;

Location	[13] Facility location (through basic modelling; interdiction, location and fortification; location-inventory modelling); [19] Strategic Facility Placement; [20] Secure location selection;
Other strategies	[1] Omni-channel retail; [2] Predefined and/or self-executing contingency plans; Ability to perform postdisruption analysis; [3] Make and buy; Revenue management; Operational mitigation; Operational contingency; Hedging; Indirect investment; Aggregate or pool demand; Have more customer accounts; Avoidance; [6] Synchronize strategic processes; Focus on sustainable supply chain; [7] Business continuity planning; Make-to-order; Make-and-buy; [11] Decision-making proximity; Business continuity plans; Social supply chain focus; Lifeline maintenance; [12] Supply chain structure; Sustainability; [13] Strategic selection of mitigation strategy; [15] Robustness; [16] Changing the supply chain management strategy to a hermetic one (closed loop); Predefined action plan for alternative scenarios in the event of emerging threats; [18] New marketing promotion; New discounts introduction; [19] Leveraging Social Media Influence; Offline-to-Online; Repurposing Assets; [20] Make-and-buy; Revenue management; Applying a new pull system called the multi Kanban system for disassembly; Adopting business continuity plannings as a formal risk management technique; Natural hedging of currency and commodity price fluctuations; Examination of the effectiveness of hybrid push-pull strategy for supply risk mitigation; Order-based production control system algorithm; Understanding diverse organisation cultures; Construction of attribute correspondence matrices for databases; [21] Redundancy;