Information value for disruption management in supply chains

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ABSTRACT

The COVID-19 crisis has revealed many weaknesses in our society. This pandemic has caused a lot of problems in businesses as well, it had a big impact on many supply chains (SC). Since an event like a pandemic is very rare, the risk is often ignored and thus preparation is not adequate. Such a risk is defined as disruption risk. The aim of this research is to increase the robustness and resilience of SCs by defining mitigation strategies against disruption risks. These strategies will concentrate on information exchange along the SC. This research will focus on defining mitigation strategies based on key performance indicators (KPIs) using a systematic literature review. Furthermore, the research will contain a survey among SC experts. The purpose of this survey is to analyze the information exchange that occurred along the SC to derive good and bad practices that companies used during the pandemic. The contributions of this research are a set of KPIs that can be shared between SC partners to mitigate the effects of disruption risks and a set of strategies that involve information sharing that allow for a more resilient and robust SC.

Keywords

Supply chain, Disruption risk, Disruption management, Information sharing, COVID-19, Ripple effect

1. INTRODUCTION

Supply chain risks often get classified into two categories; operational risks and disruption risks. Operational risks are mostly concerned with day-to-day disturbances which result from failed processes, systems, or failures caused by people [3, 12]. Disruption risk is the risk that emerges from natural disasters, man-made disasters, or pandemics. Although the chances of such events happening are low, the effects can be enormous for SCs. The COVID-19 pandemic is an example of a disruption event. The pandemic has affected businesses globally. The reason that SCs can be heavily affected in case of an epidemic is that it scales fast and disperses over many geographic regions. This results in disruptions in both supply and demand [12]. For example, the COVID-19 pandemic reduced the supply availability from China in the early days of the pandemic, and it also caused demand disruptions in Italy since the country was in lockdown. Although there have been many studies that have focused on preventing disruption in SCs [11, 18, 32], occurrences like the pandemic have proven that risk can often only be mitigated and not fully avoided.

The COVID-19 pandemic has resulted in many studies focusing on SC management during a pandemic [12, 26]. Over the past year, this field has been studied actively, the main focus of these studies was to analyze the impacts of the pandemic on SCs and defining strategies for dealing with those impacts [4]. However, a smaller part of these studies focuses on how the negative impacts on SCs can be managed preventively, which is important since due to population growth and urbanization the chances of another pandemic occurring are rather large [7]. Furthermore, the risk of a natural disaster can also never be ignored since the occurrence of these events is out of our hands. It can even be argued that humanity is influencing the occurrence of natural disasters in a negative way due to climate change. For this reason, disruption management is still an important field to be studied, since the pandemic has inadvertently proven that many SCs are not resilient to disruptive events, which became evident from events like full production standstills, to even low stock in supermarkets.

A possible strategy for SC management is information exchange between SC partners. There have been studies analyzing the value of information exchange for operational risks [28]. It can be concluded that in the case of operational risks information exchange turns out to be a very successful strategy to mitigate this risk. However, there exists a research gap when considering disruption risks.

One of the main dangers that has been identified as a result of disruptive events is the ripple effect [16]. When a disruption occurs, a negative influence of the disruption on one part of the SC can propagate through and also affect the other elements of the SC. For example, failure at one supplier to deliver materials might result in long lead times for other businesses along the SC, which can affect these businesses negatively in a financial sense. This study aims at finding strategies that can help companies to mitigate the effects of the ripple effect. Since the ripple effect concerns multiple parties along the SC, the value of information exchange has to be analyzed to reduce the impact of the ripple effect.

The goal of the research is to define mitigation strategies against disruption risks and their consequences resulting in more robust and resilient SCs. This can be achieved by analyzing the mitigation strategies in the literature. Information value will be the main focus of the study since there currently exists a research gap concerning the value of information sharing along a SC for the purpose of dis-

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ruption management. The contribution of this study is a set of KPIs that can be shared with SC partners in order to indicate deviations within the SC and with that proactively mitigate the effects of a disruptive event. Moreover, other information sharing strategies that have proven beneficial are collected and presented.

To achieve the aforementioned goal the following main research question is asked:

- What information (KPIs) can be exchanged to mitigate disruption risks and their consequences on supply chains?

To answer this question, it has been split up into two subquestions that can be answered separately:

- **RQ1:** What KPIs can be exchanged between SC partners to mitigate disruption risk?
- **RQ2:** What strategies relating to information sharing can be used to tackle the effects of disruptive events in supply chains?

The paper is structured as follows: first, a systematic literature review will be discussed. The methodology of the systematic literature review will be discussed, followed by an analysis of the gathered literature. Secondly, a survey among SC professionals will be discussed. Again, the methodology for this will be presented followed by an analysis of the results from the survey. Thirdly, the collected insights from both the systematic literature review and the survey will be presented. Eventually, this will be followed by a conclusion.

2. SYSTEMATIC LITERATURE REVIEW

2.1 Methodology

The article by Denyer and Tranfield [8] is used as a guideline to perform the SLR. This article has been used by many researchers and is considered a reliable literature review strategy. SLR is a specific methodology that can be used to perform a literature review. SLR is the most favorable choice of methodology since it requires users to collect information from different sources in an unbiased and rigorous manner. The methodology consists of five major steps. These steps are:

1. Research question formulation
2. Locating studies
3. Study selection and evaluation
4. Analysis and synthesis
5. Reporting and using the results

Since the research questions have already been formulated, the next step is to start locating studies. To achieve this multiple scientific databases were explored, these being: Scopus, ScienceDirect, and IEEE explore. To assemble a set of appropriate articles, multiple search strings were entered in these databases. The strings were adapted to fit the criteria for a search query for every database.

- (supply AND chain*) AND (disrupti*) AND (management OR risk*) AND (information AND (shar* OR exchang*)) AND (covid* OR pandemic OR virus OR corona))
- ((supply AND chain*) AND (disruption AND risk) AND (ripple AND effect))
- ((information AND sharing) AND (supply AND chain) AND (disruption AND (risk OR management)))

These search queries provided a vast amount of articles that could be used. In total, 147 appeared. However, this set of articles needed further analysis to determine whether they would contribute to the research. The third step of a systematic literature review is 'study selection and evaluation'. Denyer and Tranfield [8] suggest establishing inclusion and exclusion criteria for all articles. Every article was subjected to these criteria and the final selection of articles was made based on them. However, these criteria are mere guidelines for selection. For instance, when an article did not specifically meet one of the criteria, but the abstract suggested that the article could be useful, the decision was made to not discard it immediately. The following **inclusion** criteria were applied:

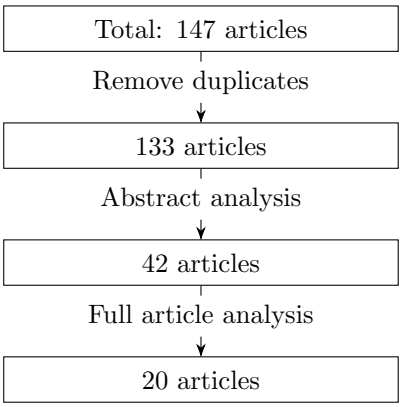

Figure 1: Article screening methodology

- Considers disruption management/disruption risk mitigation in supply chains
- Considers information exchange/sharing along the supply chain
- Considers strategies or KPIs for disruption management

Additionally, the following **exclusion** criteria were applied to directly exclude any articles that did not fit the research:

- The article is not in the English language
- Focus on operational risk, instead of disruption risk

The complete process concerning the screening of the articles is visualized in Figure 1. The search queries resulted in a total of 147 articles. The articles were first checked for duplicates, after this process 133 unique articles remained. The abstracts of these articles were then subjected to the aforementioned inclusion and exclusion criteria. After this rough elimination process, 42 articles were left. Eventually, a more thorough analysis was performed to gather insights from the articles, during this process another 22 articles were deemed not relevant. This resulted in a final set of 20 articles.

2.2 SLR overview

The final selection of 20 articles can be seen in Appendix A. This section will provide an analysis of the selected articles. The journals where the articles were published will be discussed, the methodology of the studies, the industry in which the studies have been performed, and the types of disruptive events that motivated the studies, as well as the printing years.

2.2.1 Journals of publication

All selected articles have been published in scientific journals. The majority of these articles are published in journals operating in the field of logistics (30%), production (30%), and supply chain management (SCM) (15%). Fur-

thermore, selected articles have been published in journals in the fields of economics (10%), knowledge management (KM) (5%), crisis management (CM) (5%), and operations (5%). The journal sectors are dominated by the logistics, production, and SC management fields making up 75% of articles. One would expect to find the most relevant articles in these journal fields, the remaining journal fields also fit the subject however they are less closely related to disruption management in SCs. Overall the origins of all selected articles are considered reliable sources.

2.2.2 Methodology

This section will discuss the methodologies that were applied by the researchers in the selected studies. A majority of the studies include a literature review. Within the selection, 85% of articles include a literature review. However, only 15% were solely a literature review, the other studies combined a literature review with another methodology. Most researchers used a literature review to get familiar with the subject, then this often was followed by a different class of research. This is the case since there still exists a gap in the literature regarding this topic. For this reason, many researchers chose to attempt to develop new insights, demonstrated by the number of articles that included some kind of mathematical model. Because 50% of the articles defined a model which was used in most cases to verify the validity of information sharing as a disruption management strategy. Moreover, industry insights were considered; 25% of the studies included an interview or a survey. The participants of these studies were business insiders and experts. Furthermore, 15% included a case study. Generally, the focus of the selected studies regarding information sharing is on collecting new insights through experiments and expert opinions. This is supported by existing knowledge from literature.

2.2.3 Industry

To get a possible grasp on the context in which the studies were performed, this section will provide an analysis of the industries wherein the studies were performed.

Within the selection, 15% of studies were performed in the context of the construction industry. Moreover, 10% was performed using insights from the perspective of organizations that are part of the government. And 5% was performed within the healthcare sector. The remaining studies were not performed within one specific industry. However, some of these were large-scale surveys carried out among businesses from multiple industries [2, 9, 24].

In 40% of the studies, a mathematical model was used with no specific industry in mind. These models were mentioned to be generally applicable to multiple industries. Often these models considered a two-echelon SC between a manufacturer and a retailer [33, 35], a three-echelon SC between a manufacturer, distributor, and a retailer [22], or a four-echelon SC between a manufacturer, wholesaler, distributor, and a retailer [5, 6, 30].

2.2.4 Disruptive event types

All selected articles consider disruption management, often the motivation behind these studies is a specific disruptive event. New insights can be gathered from analyzing the types of disruptive events that motivated the authors. The COVID-19 crisis is one of the largest disruptive events in recent history, many researchers were motivated to explore the impact of the pandemic. From the selected articles, 30% were motivated by the COVID-19 pandemic. Generally speaking, these studies focused on reactive strategies to combat the effects of the virus on

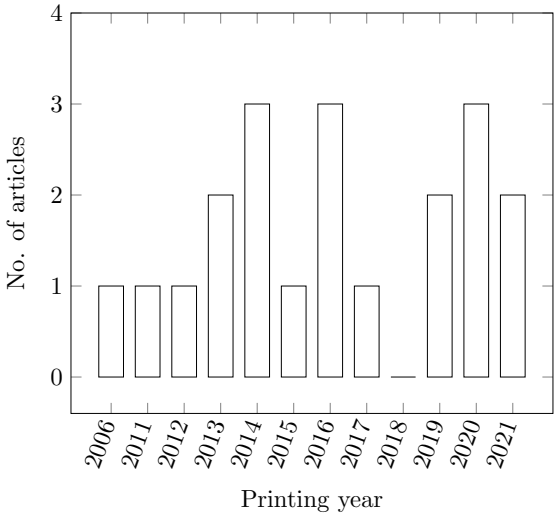

Figure 2: Printing years of selected articles

SCs. Furthermore, 15% of studies were motivated by man-made disasters. They argue that these types of disruptive events are not as rare as we might expect. Due to more global SCs, there is more room for man-made error which increases the chance of a disruptive event [2]. Another 10% of studies had natural disasters as a motive. The remaining 45% did not have a specific disruptive event as motivation for their research.

2.2.5 Printing year

The selection of articles was published mostly in the last decade, the one exception is the article by Li et al [21], which is a slightly older article. The rest of the article was published somewhat evenly over the past decade. This gives a broad perspective into articles pre-and-post COVID-19. The distribution of printing years can be found in Figure 2.

3. SURVEY

3.1 Methodology

Performing a survey is a process that requires attention to obtain high-quality results with real value. To accomplish this the article by Kelley et al. [17] was used as a guideline. The article provides a checklist of good practices when conducting and reporting survey research. The goal of the paper is to guide researchers to a result that can be considered credible.

The survey focuses mainly on the verification of collected insights from the SLR. Since there exists a gap in the field of information value for disruption management, it is desirable to confirm the obtained results with practitioners in the field. Furthermore, the survey provides the option for participants to provide new insights from their own experiences as well. However, the main topic of the survey will be confirming the collected insights from the SLR.

The method for this study is descriptive research, which aims to gather information on certain phenomena, often at a single point in time. The nature of this study is to collect insights and verify the obtained results from the SLR. For this reason, descriptive research suffices to obtain the desired results. Moreover, the survey will be a postal questionnaire as defined by Kelley et al. [17]. A disadvantage of this method is the generally low response rate. This means a relatively large sample is desired to obtain a credible result. A large sample is also desirable for this

paper because the research is not focused on any particular industry. Thus, ideally as many industries as possible would be represented, which requires a larger sample.

The target group of the survey consists of SC professionals. Although many companies require someone who manages the SC, it is difficult to reach out to them without the proper network. Most respondents will be suitable since most who are currently working with SCs have experience with a major disruptive event; the COVID-19 pandemic. SC professionals are people who currently are, or recently were: managing, optimizing, advising on, studying, or designing SCs. However, the survey also collects the job description of the participants. This means each case can be considered individually when analyzing whether the participant fits the target group.

The survey was conducted anonymously. However, some data was collected to differentiate the participants and possibly find insights based on one of the collected identifiers. These identifiers were: the industry of the company of the participant, the job description of the participant, and the size of the company of the participant.

The remaining part of the survey was divided into two parts. The first part consists of questions about shareable KPIs, and the second part consists of questions about strategies in the context of information sharing. The KPI section was structured as follows: respondents were asked to rate each KPI collected from literature on what the impact of sharing it with their SC partners would be. They were asked to rate this on a scale from one to five. Where one is: 'Very negative impact', and five is: 'Very positive impact'. The respondents were also asked to leave remarks on their responses, as well as to provide other KPIs that weren't mentioned that could be shared with a positive effect.

The strategy section was structured slightly differently. The respondents were asked to rate each strategy collected from literature on how effective they believe it would be if applied at the company they work for. They were asked to rate the efficiency on a scale from one to ten. In addition, they were asked to explain why they rated the strategies as they did.

3.2 Descriptive analytics

The survey was filled out by eight SC professionals. One part of the survey asked the respondents to rate the efficiency of the KPIs that resulted from the SLR. Since the sample group is small, it is important to be critical of any numerical analysis. This also holds for the part of the survey that asked to rate the impacts of the strategies that resulted from the SLR, these results should also be critically analyzed. The focus of using the results of the survey will be more on using the explanation that was asked after every rating and look for insights in these more detailed answers. The individual answers to all questions can be seen in Appendix B.

3.2.1 Industry

All respondents were asked to indicate in what industry their company operates. However, it was noted that they should be comfortable with giving this information since the survey is anonymous. For this reason, five respondents indicated the industry of their company. Of these five none were in the same specific industry, however for the sake of this research is it most relevant to know where they are located in the SC. A basic four-echelon SC consists of a manufacturer, which passes its products on to a wholesaler, who transports products to a distributor, who

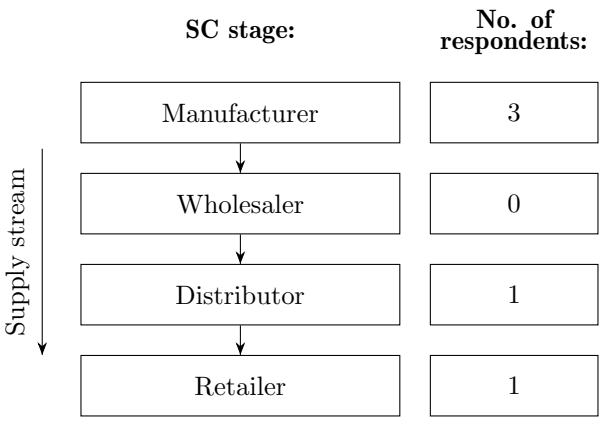

Figure 3: Four echelon supply chain [29] with number of respondents

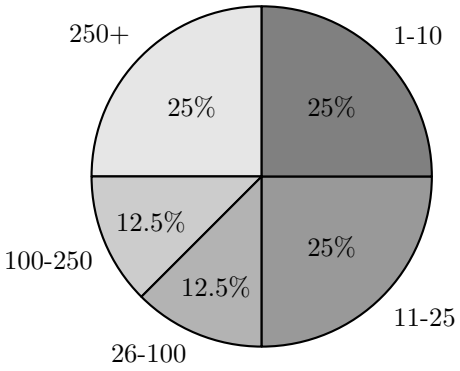

Figure 4: Distribution of amount of employees

spreads the products to the retailer. Eventually, the retailer sells the products to consumers [29]. This structure can also be found in Figure 3. This shows that three manufacturers, one distributor, and one retailer have filled out the survey.

3.2.2 Company size

The respondents were asked to indicate the number of people their company employs. This information can be used to discover possible relations between company size and the usability of KPIs and strategies.

The Dutch government defines small and-medium sized enterprises (SMEs) as companies with fewer than 250 employees [23]. From the respondents, 75% indicated that the company they are working for falls into this category. A more detailed breakdown of the company size can be found in Figure 4. As can be seen, 50% of respondents works at a company with less than 25 employees, 12.5% worked at a company with 26-100 employees, and another 12.5% worked at a company with 100-250 employees.

3.2.3 Job description

The respondents were asked to indicate their job descriptions. This was done to qualify them as valid respondents, as well as to possibly find any relations between the answers of respondents with the same function.

The results show that three of the respondents had leading roles such as director. They were regional director, general director, and commercial director. Their specialty is not necessarily SC management, however, they have enough knowledge on all levels of a company to qualify for this

research. One respondent was a manager, they qualify for the same reason as a director. Furthermore, two of the respondents described themselves as SC planners. They are generally the person within a company who is most concerned with the SC so they also naturally qualify as being SC experts for this research. Finally an operational manager and a business process expert logistics filled in the survey. Both are concerned with business processes, which means they also work with SCs.

4. RESEARCH FINDINGS

The goal of the research is to find answers to the proposed research questions. During the SLR the focus was on identifying KPIs that were discussed as being shareable or exchangeable between parties along the SC, with the goal of mitigating disruption risk. These insights will help in answering RQ1. Furthermore, risk mitigation strategies were collected that were discussed in the articles, these insights will help in answering RQ2. The point of collecting KPIs and strategies is to develop a set of guidelines that can be followed to mitigate disruption risk and its consequences. This section will provide the insights gathered from the SLR and the survey, the section will be split into two parts: the collected KPIs and the collected strategies.

4.1 Key performance indicators

Information sharing is a strategy that can be accomplished by many different means. This research uses KPIs as shareable information. KPIs are often measured in a standardized way by companies to enable comparability, this means different SC collaborators can easily understand KPIs from different organizations which helps them to get true value out of it when shared. Furthermore, it is favorable to have a quick communication system [33], this means information has to be readily understandable by all parties. KPIs provide this understandable way of communication, which yields a very efficient way of sharing information. The result of the analysis regarding the collected KPIs can be found in Table 1.

Before the individual KPIs will be discussed in more detail, a point should be made about the strenuous process of information sharing. In this research, information sharing is defined as a mitigation strategy. Information sharing often is done in a proactive way, that is to say, that SC partners will be exchanging possibly sensitive information continuously. However, according to multiple researchers, this causes problems. For example, companies are afraid that their sensitive information will end up in the hands of their competitors [2]. Other research found that there are security concerns [9], which resulted in a conclusion that companies are mostly only open to sharing less sensitive KPIs like delivery times.

There are proposed solutions to this problem. Distinguishing information between shareable and non-shareable information, where non-shareable information refers to the information which may cause undesirable chaos and risks such as relational, image, and competition risks when they are shared [2]. The problem with this solution is that only partially sharing information will not have the full effect.

At the end of the day, the goal is to be open about your information. Although it might seem there are a lot of direct disadvantages to proactive information sharing, this research has also focused on the validity of information sharing in general as a strategy. The result of this is that almost every article explicitly mentions the validity of information sharing as a disruption management strategy. Moreover, not one article of the selection mentions that information sharing is not a valid strategy. The problem with disruptive events is that they are rather rare, which entices companies to not invest in mitigating the effects of these events beforehand. However, the research proves that it is worth considering the potential effect, and information sharing therefore is a valid strategy.

Table 1: Typical KPIs shared between companies

KPI	Source (Reference no.)
Inventory level	[1] , [5], [6], [13], [19], [22], [29], [30], [33], [35]
Demand	[1], [5], [9], [19], [21], [25], [29], [30], [31], [35]
Production capacity	[19], [22], [29], [33], [34]
Transportation time	[9], [14]
Sales/Profit	[13], [34]
Lead time	[13], [30]
Service level	[13]
Order fulfillment	[29]

This is also supported by the results from the survey. The respondents were asked to rate to what extent they would be willing to shared KPIs with SC partners. The average response to this question was an 8, with the lowest response being a 7. This indicates that companies are interested in risk-mitigating through SCs. However, almost every respondent also mentioned that there are risks involved with information sharing, which connects to the literature.

The next part of this chapter will be used to discuss the mentioned KPIs in more detail.

4.1.1 Inventory level

Inventory level refers to the number of items a company keeps in stock to process or resell. Often, when the inventory level differs from the norm, in a sense that the level is either too high or too low for a prolonged amount of time, it can be the result of a disruptive event. Therefore, it can prove beneficial to share this KPI with SC collaborators to keep them updated on any deviations from the norm. Some SC collaborators might later experience the effects when their inventory level is impacted, this effect will continue moving downstream throughout the SC, which is more commonly known as the aforementioned ripple effect [14].

By sharing their inventory level, a company has more insight into the operational level of a collaborator and then is able to estimate the present ability of that collaborator to deliver the required amount of products timely. A common result of this is a reduction in the number of accumulated backorders by adjusting the order ratio [33]. However, full elimination of backorders is usually not possible.

To combat this effect a strategy that involves sharing inventory levels is discussed by Constantino et al. [5]. This strategy proposes a method where the inventory level is shared in a useful way in combination with sharing demand, which is another collected KPI that will be discussed later. The idea behind this strategy is that there should be more visibility into the contents of an order. The proposed strategy relies on dividing placed orders into two streams: one stream consists of the real demand information, the second stream includes the required inventory adjustments in order to keep a stable inventory. According

to the research, this strategy results in a reduced stabilization period of the inventory level after a disruptive event, which in turn proved to mitigate the effects of the ripple effect.

The respondents of the survey are mostly positive about sharing inventory level as KPI. Most of the respondents (63%) judged this KPI as having a 'somewhat positive impact' on mitigating disruption risk when the KPI is shared.

4.1.2 Demand

Demand is closely related to inventory level since one can directly influence the other. Still, in the context of information sharing, they are different, as proven by the aforementioned strategy [5] that involves sharing inventory level and demand as separate values. They might influence each other, but different conclusions can be drawn from sharing them individually.

Demand is defined as the quantity of a good that buyers are willing and able to purchase at various prices during a given period of time. Demand regularly shifts, especially in case of a disruptive event. When you are a supplier, downstream SC partners might suddenly require much more or fewer goods. These sudden changes in demand are known as demand spikes [30]. One can argue that demand is already shared when an order is placed at a supplier since the order specifies how many goods the buyer requires. However, demand is often inconsistent and can change rapidly. For this reason, it can be beneficial to share demand with an upstream supplier on a regular basis. This allows the supplier to prepare for demand spikes.

When demand is only transferred throughout the SC in the form of orders, major problems can occur. This is the case because it has been proven that when demand moves up the SC in this form it can very easily be distorted and amplified. Especially in the case of a demand spike, a drastically divergent order from a retailer upstream to a wholesaler can spook the wholesaler into also placing an even larger order to their manufacturer. Eventually, this may cause inventory problems at many stages in the SC. This effect has been widely studied and was labeled as the bullwhip effect by Lee et al. [20]. To counteract this effect, it has proven useful to share demand more openly and more often. Doing so mitigates the risk of experiencing the effects of the bullwhip effect [5].

Demand as a shareable KPI was rated very well by the SC experts. Most respondents (50%) judged sharing demand as having a 'very positive impact' on mitigating disruption risk.

4.1.3 Production capacity

Production capacity is defined as the maximum production output a business has using the available resources. Many parties within SCs keep track of their production capacity to ensure they can supply their customers. However, some parties like a retailer, who are often located at the end of the SC, do not produce or manufacture any products by themselves. Their goal is to sell their products to consumers. Production capacity is mostly shared with upstream SC partners since they are responsible for delivering their materials or products to their suppliers. Production capacity can be shared as a KPI that communicates the amount of product that can be produced, this can extend in also sharing the production schedules. Besides providing the number of products that can be produced, it can also be beneficial to provide the times when a certain amount of products can be produced. The model presented in the article by Kumar and Anbanandam [19] argues this concept. In their model production capacity and production schedules are visible to SC partners. When the parties acted on the shared information by changing the order or changing the production mix, the result was a more resilient SC.

Production capacity was not consistently judged by the surveyed SC professionals, the respondents did not rate it in one direction. Most rated the KPI as having a 'neutral impact' (38%), further both 'somewhat positive effect' and 'somewhat negative effect' were selected by 25% of respondents. Which does not show any clear outcome.

4.1.4 Transportation time

Transportation or delivery times can be shared in order to update SC partners on the status of an order. Especially in times of disruption, transportation is often affected in a major way. A natural disaster, for example, can block important trade routes which can result in big delays. Transportation times can be communicated as KPIs in the form of on-time shipping, which is the percentage of shipments that arrived within the specified time frame.

However, transportation time can also be shared in other forms than just KPIs. Recent advances in technology have popularised the use of track and trace systems, which allows parties to monitor a shipment live. Track and trace systems can be used in a proactive manner, they can be utilized to identify deviations or danger of deviations in a timely manner [14]. Due to the fact that live data is utilized, these disruptions can be effectively communicated to SC partners to minimize the effect of the disruption. For example, initial schedules can be revised before the effects of a disruption are felt.

The results of the survey were positive towards sharing transportation times. Most respondents (63%) judged the KPI as having a 'somewhat positive impact' on mitigating disruption risk when the KPI is shared. It was noted that sharing transportation time will very likely not have a negative impact, since it is in most cases not sensitive information to a company.

4.1.5 Other KPIs

The SLR resulted in four other shareable KPIs: Sales/profit, lead time, service level, and order fulfillment. These KPIs were found to not having enough sources mentioning them as important KPIs in the context of mitigating disruption risks, or the result from their respective research did not prove to have a positive impact on the SC. Another criteria that was used to judge the effectiveness of the KPIs were the results of the survey. For these reasons, they will not be considered as shareable KPIs based on the findings of the SLR. However, this does not mean that they do not have the potential to have a positive effect, there simply does not exist enough evidence in the selected articles that they will positively impact the SC in case of a disruption.

The survey was used in case of the KPI: sales/profit. Since 50% of the respondents rated it as: 'Neutral impact' and 25% as 'Somewhat negative impact'. Combined with the limited amount of mentioning in the literature, not enough proof is available to show that this KPI has a positive impact on mitigating disruption risks.

4.2 Strategies

This section will explore the results from the SLR concerning strategies for disruption management, this will be used to answer RQ2. The focus of these strategies is on mitigating the risk resulting from disruptive events. The

Table 2: Strategies to mitigate disruption risk

Strategy	Source (Reference no.)
Full information sharing	[2], [5], [6], [10], [13], [14], [19], [21], [22], [25], [29], [30], [31], [33], [34], [35]
Partial information sharing	[2], [22], [33]
Visibility	[1], [19], [30]
Digitalization	[9], [14], [31]
Collaborative forecasting	[10], [29]
Risk-sharing contracts	[34]

strategies that were collected are related to information sharing since this was also the direction of the SLR. Some of these strategies can be deployed using the discussed KPIs. The collected strategies can be found in Table 2.

4.2.1 Full & partial information sharing

The collected KPIs mentioned before were selected with information sharing as a general strategy in mind. The KPIs that were proven to be beneficial are well suited to be communicated up and downstream with SC partners. It is however important when sharing this information, to analyze in what direction information should be shared. It was found that in some situations certain KPIs did not show to have any effect when shared in a certain direction. For example, it was shown that sharing demand only has an effect when shared upstream, e.g. from a retailer to a manufacturer, this helped to mitigate the order variance for both parties [30]. For this reason, it is argued that it is important to determine the direction of information flows.

Furthermore, some articles acknowledged the distinction between full and partial information sharing. Partial information sharing refers to only sharing a certain amount of the available KPIs, or only sharing a limited amount of data concerning a KPI. It is often considered when modeling SCs to obtain data on different scenarios [22]. Partial information sharing can be considered as a strategy when a party is worried about sharing data that might end up in the hands of the competition. In all selected studies from the SLR, when researchers used a model to test the validity of partial and full information sharing, the result was in all cases that full information sharing is more beneficial than partial information sharing in terms of reduced backorder amount and duration [22, 33]. Which results in a positive financial effect.

4.2.2 Visibility

Visibility in SC management refers to having the knowledge of where components, products, and raw materials are at any particular time in the SC, in other words, it is the ability to see through the entire SC from one end to the other [19]. Full visibility of this information requires intense collaboration between SC partners since almost all parties have to collaborate to reach a state of full visibility. Visibility has proven to result in risk reduction, its presence helps organizations proactively track products and identify potential disruptions [1]. To reach full visibility, it is suggested that two resources are necessary: SC connectivity and quality information sharing. Connectivity refers to a technological infrastructure that has to be in place, in order to timely transmit information. And quality information sharing refers to the nature, speed, and quality of the information that is shared [1].

In light of the COVID-19 pandemic, the results from the expert survey are also positive towards visibility as a disruption management strategy. It is mentioned that visibility along the whole SC could have allowed for a more timely response to the pandemic. However, it was also mentioned that the impact of the pandemic could naturally not have been fully avoided. Still, the effectiveness of the strategy was graded 7.9 on average on a scale of one to ten among SC experts.

4.2.3 Digitalization

The term digitalization in the context of SCs is often confused with digitization. However, they are different, since digitization is often necessary for the process of digitalization. Digitization refers to the process of converting analog data into a digital model, whereas digitalization refers to the impact that this digitized data has on the SC in organizational and societal perspectives [27]. But these days most companies have already digitized over the past years and are ready for more intense digitalization.

Digitalization offers many opportunities for companies in general, as well as digital information sharing as a strategy [9] which is an enabler for flexibility in pre-and post disruptive phases. However, digitalization will also play a major role in guiding companies into Industry 4.0 [14], in which objects and machines can interact with each other, supported mainly by the internet of things, cyber-physical systems, artificial intelligence, and big data analytics, among other technologies [27]. Ivanov et al. [14] found that the interplay of digitalization and Industry 4.0 with regard to the ripple effect is still considered vague. This is still a research gap in this regard and should be explored further.

The survey showed no clear consensus on digitalization as a strategy. The results were very mixed and not much clarification was given by the respondents.

4.2.4 Collaborative forecasting

Collaborative forecasting is a process that involves openness to the entire SC. Companies spend billions worldwide on accurate demand forecast information, this is done because the accuracy of the demand forecast is vital to not only the company itself but also to partners [29]. A strategy that can mitigate this effect is collaborative forecasting. Decisions on demand levels can be made in collaboration with up and downstream SC partners, which can provide the partners in the chain with the outlook one firm is having.

The simulation model described by Samvedi and Jain [29] tests the validity of collaborative forecasting under different levels of disruption. The model was tested under the effects of no disruptions, supply disruptions, demand disruptions, and a combination of the latter two. They conclude that under every tested circumstance collaborative forecasting has a positive impact, although in certain circumstances this impact is small.

The results from the survey show mixed opinions on the effectiveness of collaborative forecasting. It is noted multiple times that such a strategy is most effective for larger companies that mass produce. For smaller, specialized businesses the strategy is rated less effective. Under companies with less than 100 employees, the average grade is 6.5 when asked how effective they believe the strategy to be, whereas companies with more than 100 employees graded the strategy a 9.3 regarding the same question.

4.2.5 Risk-sharing contracts

It is argued that success in SCs stems from a long-term commitment and trust between partners [34]. One way to

achieve long-term commitment is the ability to share the risk as well as the benefits regarding actions in the SC. A strategy that is based around this concept is the use of risk-sharing contracts.

Risk-sharing contracts are known to be efficient in times of disruption since they force partners to coordinate when facing uncertain demand [34]. Their efficiency proceeds from the risk mitigation that is offered by sharing the risk. Both parties will agree on such a contract since they have reassurance in case of a disruptive event. It is however stated that although the risk is mitigated for all parties, not all parties might benefit equally. Certain parties might benefit regarding costs, but since the risk is mitigated there still exists plenty of reason to consider risk-sharing contracts within SCs.

5. CONCLUSION

This study adds to the research field of disruption management for supply chains by answering the two research questions. This was accomplished by performing a systematic literature review in combination with a survey among supply chain professionals to verify the results from the gathered literature. The results from these processes were used to answer the research questions, which resulted in a set of KPIs that can be shared with SC partners, and a set of strategies in the context of information sharing.

The first research question has been answered by collecting a set of KPIs that can be shared between supply chain partners in order to mitigate disruption risk. The KPIs that have been proven by multiple studies to be beneficial have been collected. They can all be shared with different positive effects. These gathered KPIs are: Inventory level, demand, production capacity, transportation. They can be shared with SC partners, and they can all be shared simultaneously. However, some KPIs have proven to have a greater positive effect when shared in a certain direction within the supply chain; either upstream or downstream.

The second research question focused on the effect of information sharing strategies on supply chains under disruptive events. To answer this question multiple strategies were retrieved from the literature. They were analyzed and discussed, and a set of strategies was discussed which proved to have a positive effect on mitigating disruption risk in supply chains. The first strategy is information sharing, either with full openness or with partial sharing. The aforementioned KPIs can be shared in this strategy. The other strategies that were found to be beneficial are visibility, digitalization, collaborative forecasting, and risk-sharing contracts.

This research fills the research gap on information value for disruption management by defining a set of KPIs and a set of strategies that have been proven to be beneficial to mitigating disruption risk in supply chains.

5.1 Limitations

The study is limited in some areas. It has proven very difficult to gather a large number of respondents when performing a survey. This research can be improved by gathering more respondents to the survey by deploying the survey over a longer period of time and getting access to a larger network in the field of SCM. Furthermore, since the SLR was conducted with no prior experience, it was not done in the most efficient manner. If the literature research were performed in a more efficient manner, more insights could possibly be gathered from more sources and the review would have been more rigorous.

5.2 Future work

In the future, this research could be expanded upon by performing experiments on the collected KPIs and strategies to determine their effectiveness in a more practice-oriented manner, since the findings of this research originate from literature. Furthermore, one of the findings of the survey was that some KPIs have different effects depending on company size according to the surveyed SC experts. This relation should be explored more thoroughly to determine what KPI is effective in what situation.

Moreover, the willingness of companies to share the collected information should also be explored more. This is also still a research gap and the effectiveness of the KPIs that were collected is dependent on whether companies are willing to share with direct partners.

Lastly, it should be further explored what the exact implications are of sharing the collected KPIs in certain directions. Since upstream and downstream information sharing can have different effects depending on the KPI.

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7. REFERENCES

[1] E. Brandon-Jones, B. Squire, C. W. Autry, and K. J. Petersen. A contingent resource-based perspective of supply chain resilience and robustness. *Journal of Supply Chain Management*, 50(3):55–73, 2014.

[2] Y. Can Saglam, B. Sezen, and S. Y. Çankaya. The inhibitors of risk information sharing in the supply chain: A multiple case study in turkey. *Journal of Contingencies and Crisis Management*, 28(1):19–29, 2020.

[3] J. Chen, A. S. Sohal, and D. I. Prajogo. Supply chain operational risk mitigation: a collaborative approach. *International Journal of Production Research*, 51(7):2186–2199, 2013.

[4] P. Chowdhury, S. K. Paul, S. Kaisar, and M. A. Moktadir. Covid-19 pandemic related supply chain studies: A systematic review. *Transportation Research Part E: Logistics and Transportation Review*, 148:102271, 2021.

[5] F. Costantino, G. Di Gravio, A. Shaban, and M. Tronci. Information sharing policies based on tokens to improve supply chain performances. *International Journal of Logistics Systems and Management*, 14(2):133–160, 2013.

[6] F. Costantino, G. Di Gravio, A. Shaban, and M. Tronci. Replenishment policy based on information sharing to mitigate the severity of supply chain disruption. *International Journal of Logistics Systems and Management*, 18(1):3–23, 2014.

[7] C. W. Craighead, D. J. Ketchen Jr., and J. L. Darby. Pandemics and supply chain management research: Toward a theoretical toolbox*. *Decision Sciences*, 51(4):838–866, 2020.

[8] D. Denyer and D. Tranfield. *Producing a systematic review*, pages 671–689. Sage Publications Ltd, Thousand Oaks, CA, 2009.

[9] M. Doetzer and A. Pflaum. The role of digitalized information sharing for flexibility capability utilization: lessons from germany and japan.

International Journal of Physical Distribution and Logistics Management, 2021.

[10] D. Friday, D. A. Savage, S. A. Melnyk, N. Harrison, S. Ryan, and H. Wechtler. A collaborative approach to maintaining optimal inventory and mitigating stockout risks during a pandemic: capabilities for enabling health-care supply chain resilience. *Journal of Humanitarian Logistics and Supply Chain Management*, 2021.

[11] I. Heckmann, T. Comes, and S. Nickel. A critical review on supply chain risk – definition, measure and modeling. *Omega*, 52:119–132, 2015.

[12] D. Ivanov. Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (covid-19/sars-cov-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136:101922, 2020.

[13] D. Ivanov. Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (covid-19/sars-cov-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136, 2020.

[14] D. Ivanov, A. Dolgui, and B. Sokolov. The impact of digital technology and industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research*, 57(3):829–846, 2019.

[15] D. Ivanov, A. Dolgui, B. Sokolov, and M. Ivanova. Disruptions in supply chains and recovery policies: state-of-the art review. *IFAC-PapersOnLine*, 49(12):1436–1441, 2016.

[16] D. Ivanov, B. Sokolov, and A. Dolgui. The ripple effect in supply chains: trade-off 'efficiency-flexibility-resilience' in disruption management. *International Journal of Production Research*, 52(7):2154–2172, 2014.

[17] K. Kelley, B. Clark, V. Brown, and J. Sitzia. Good practice in the conduct and reporting of survey research. *International Journal for Quality in Health Care*, 15(3):261–266, 2003.

[18] P. R. Kleindorfer and G. H. Saad. Managing disruption risks in supply chains. *Production and Operations Management*, 14(1):53–68, 2005.

[19] S. Kumar and R. Anbanandam. An integrated delphi – fuzzy logic approach for measuring supply chain resilience: an illustrative case from manufacturing industry. *Measuring Business Excellence*, 23(3):350–375, 2019.

[20] H. L. Lee, V. Padmanabhan, and S. Whang. Information distortion in a supply chain: The bullwhip effect. *Management Science*, 43(4):546–558, 1997.

[21] G. Li, Y. Lin, S. Wang, and H. Yan. Enhancing agility by timely sharing of supply information. *Supply Chain Management*, 11(5):425–435, 2006.

[22] H. Li, G. Pedrielli, L. H. Lee, and E. P. Chew. Enhancement of supply chain resilience through inter-echelon information sharing. *Flexible Services and Manufacturing Journal*, 29(2):260–285, 2017.

[23] Netherlands Chamber of Commerce and Netherlands Enterprise Agency. What is an sme?. *https://business.gov.nl/starting-your-business/first-steps-for-setting-up-your-business/what-is-an-sme/*, 2021. Accessed: 22-06-2021.

[24] O. Omoruyi and E. Akuoma. The influence of supply chain management on the performance of small to medium enterprises in southern gauteng. *International Journal of Economics and Finance Studies*, 12(1):172–188, 2020.

[25] S. Ponis and E. Koronis. Inter-organizational knowledge transfer for supply chains in crisis. In *Proceedings of the European Conference on Knowledge Management, ECKM*, volume 2, pages 569–576, 2013.

[26] M. M. Queiroz, D. Ivanov, A. Dolgui, and S. F. Wamba. Impacts of epidemic outbreaks on supply chains: mapping a research agenda amid the covid-19 pandemic through a structured literature review. *Annals of operations research*, pages 1–38, 2020.

[27] M. M. Queiroz, S. C. F. Pereira, R. Telles, and M. C. Machado. Industry 4.0 and digital supply chain capabilities. *Benchmarking: An International Journal*, 28(5):1761–1782, 2021.

[28] T. Ramayah and R. Omar. Information exchange and supply chain performance. *International Journal of Information Technology and Decision Making*, 09(01):35–52, 2010.

[29] A. Samvedi and V. Jain. Effect of sharing forecast information on the performance of a supply chain experiencing disruptions. *International Journal of Logistics Systems and Management*, 13(4):509–524, 2012.

[30] S. Sarkar and S. Kumar. A behavioral experiment on inventory management with supply chain disruption. *International Journal of Production Economics*, 169:169–178, 2015.

[31] J. B. Skipper, D. J. Hall, B. T. Hazen, and J. B. Hanna. Achieving flexibility via contingency planning activities in the supply chain. *International Journal of Information Systems and Supply Chain Management*, 7(2):1–21, 2014.

[32] C. Tang. Perspectives in supply chain risk management: A review. *International Journal of Production Economics*, 103:451–488, 2005.

[33] Y. Tao, L. H. Lee, and E. P. Chew. Quantifying the effect of sharing information in a supply chain facing supply disruptions. *Asia-Pacific Journal of Operational Research*, 33(4), 2016.

[34] T. Wakolbinger and J. M. Cruz. Supply chain disruption risk management through strategic information acquisition and sharing and risk-sharing contracts. *International Journal of Production Research*, 49(13):4063–4084, 2011.

[35] T. Yang and W. Fan. Information management strategies and supply chain performance under demand disruptions. *International Journal of Production Research*, 54(1):8–27, 2016.

APPENDIX

A. FINAL ARTICLE SELECTION

Ref. no.	Title
[1]	A Contingent Resource-Based Perspective of Supply Chain Resilience and Robustness
[2]	The inhibitors of risk information sharing in the supply chain: A multiple case study in Turkey
[5]	Information sharing policies based on tokens to improve supply chain performances
[6]	Replenishment policy based on information sharing to mitigate the severity of supply chain disruption
[9]	The role of digitalized information sharing for flexibility capability utilization: lessons from Germany and Japan
[10]	A collaborative approach to maintaining optimal inventory and mitigating stockout risks during a pandemic: capabilities for enabling health-care supply chain resilience
[13]	Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case
[14]	The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics
[15]	Disruptions in supply chains and recovery policies: state-of-the-art review
[19]	An integrated Delphi – fuzzy logic approach for measuring supply chain resilience: an illustrative case from manufacturing industry
[21]	Enhancing agility by timely sharing of supply information
[22]	Enhancement of supply chain resilience through inter-echelon information sharing
[24]	The influence of supply chain management on the performance of small to medium enterprises in southern gauteng
[25]	Inter-organizational knowledge transfer for supply chains in crisis. Proceedings of the European Conference on Knowledge Management
[29]	Effect of sharing forecast information on the performance of a supply chain experiencing disruptions
[30]	A behavioral experiment on inventory management with supply chain disruption
[31]	Achieving flexibility via contingency planning activities in the supply chain
[33]	Quantifying the Effect of Sharing Information in a Supply Chain Facing Supply Disruptions
[34]	Supply chain disruption risk management through strategic information acquisition and sharing and risk-sharing contracts
[35]	Information management strategies and supply chain performance under demand disruptions

B. SURVEY RESULTS

General	RESPONDENT 1	RESPONDENT 2
What industry does your company operate in?	Linear Actuator (Electronic components) Industry	In de bouw en industrie, als toeleverancier van de bouw en industrie.
What is the size of your company? (Amount of employees)	1-10	100-250
What is your job description?	Manager / Head of Product Development	Commercieel Directeur
Many researchers have found that companies are not always willing to share information. Examples of shareable information (KPIs) are: inventory levels, delivery times, etc. How willing would you be (or are you already) to share such KPIs with your upstream & downstream supply chain partners?	8	7
Do you believe there are any problems with sharing this information (KPIs)? If so, please explain what in the blank field below.	Information on delivery times should not be shared (or at least not completely truthfully) with your suppliers in order to have a little bit of safety time (for unexpected occurrences) left.	Sommige kpi's zijn om intern te monitoren en bij te sturen en kunnen concurrentie gevoelig zijn.
The COVID-19 pandemic has had a big impact on many supply chains worldwide. Please explain if the pandemic had any impact on your supply chain. If the answer is yes, please explain what this impact was. If possible, please go into detail about the effect on the whole supply chain. (For example; did you notice any signs of the ripple effect: This is when a disruption at one point in the supply chain moved (or 'rippled) through many parties within the supply chain.)	experience of longer delivery times (especially from suppliers overseas) that also delayed our deliveries (if not enough buffer time and/or inventory on stock -- penalties), supplier(s) had to be changed to more reliable ones (better rating, more local, shorter delivery times), communication issues (due to COVID often home office and people not reachable)	Ja, de toelevering vanuit met name Azië van grondstoffen, halffabrikaten en eindproducten is even vertraagd geraakt.
KPIs		
This question lists a set of KPIs that were found in the literature as information that can be shared within the supply chain that has a positive effect. Imagine you adapt information sharing as a proactive disruption risk management strategy within your supply chain. Proactive suggests that information is shared on a regular basis, before a disruptive event occurs. Please indicate what effect you believe it would have on your own business to share the mentioned KPI.		
[Inventory level]	Somewhat postive impact	Somewhat postive impact
[Demand]	0	Neutral impact
[Production capacity]	Neutral impact	Somewhat negative impact
[Sales/profit]	Neutral impact	Somewhat negative impact
[Lead time]	Somewhat postive impact	Neutral impact
[Delivery time]	Somewhat postive impact	Somewhat postive impact
[Service level]	Neutral impact	Very positive impact
[Order fulfilment]	Neutral impact	Somewhat postive impact
If you have any remarks regarding this question please feel free to elaborate:	crossed neutral for many aspects as I think that sharing such information can be beneficial, but only with companies you trust (otherwise it might be used against you or you are replaced by another one)	0
From your own experience, is there any other information that you believe can be shared between upstream and downstream supply chain partners with a positive effect? These could be KPIs that were not mentioned before, or something completely different.	general situation/developments in a country (e.g., the REE "crisis") of an overseas supplier that is visible already long before it comes into the media (or reaches Europe in that case) - to predict upcoming spikes in time	0
Strategies		
Visibility: The impacts of a disruptive event can be mitigated by having full visibility along a supply chain of the raw materials, components and products and their locations. This requires a combined effort by partners along the supply chain. To what extent do you believe this is an effective strategy?	10	8
Please elaborate on your last answer about effectiveness of 'visiblity' as a disruption management strategy.	sharing of information and being transparent: very important, but effects of e.g., COVID could not have been fully avoided also by having had this information (external effects)	Als partners ben je zo in staat elkaar pro actief te helpen en ik sneller in te spelen op issues in de SUPPLIERS chaim
Collaborative forecasting: Planning the orders in collaboration with your supplier. If this strategy is properly executed, there should be less backorders. This strategy does require intense collaboration. To what extent do you believe this is an effective strategy?	7	10
Please elaborate on your last answer about effectiveness of 'collaborative forecasting' as a disruption management strategy.	VMI and CPFR are good strategies, but not always applicable. We use so many (comparably minor) suppliers (e.g., for C-parts like screws) and they change basically every time (dependent on the price) that collaborative planning would not be worth the effort.	Zie eerder antwoord
Flexibility: The ability as a company to easily adapt to situations. Examples; back-up suppliers, back-up depots and transportation channels, inventory and capacity buffers, capacity expansion. This strategy is great for reacting to a disruptive event, but it takes time and money to manage back-up options. To what extent do you believe this is an effective strategy?	5	7
Please elaborate on your last answer about effectiveness of 'flexibility' as a disruption management strategy.	flexibility for responsiveness strategy: agree, but strategy is often being cost-efficient (and there you have to stay lean and with that take a bit of risk)	0
Digitalisation: Making supply chain information digitally available for supply chain partners. This strategy allows for almost instant data sharing when a digital system is in place, however security might be a concern when all your data is available online. To what extent do you believe this is an effective strategy?	5	7
Please elaborate on your last answer about effectiveness of 'digitalisation' as a disruption management strategy.	effective, yes, but not applicable for our small company yet (simple input/output, many manual things), rather traditional industry (partners not used to it, only helpful if entire value chain is on board).	0

General	RESPONDENT 3	RESPONDENT 4
What industry does your company operate in?	Retail	0
What is the size of your company? (Amount of employees)	250+	11-25
What is your job description?	Supply chain planner	Operational Manager
Many researchers have found that companies are not always willing to share information. Examples of shareable information (KPIs) are: inventory levels, delivery times, etc. How willing would you be (or are you already) to share such KPIs with your upstream & downstream supply chain partners?	8	7
Do you believe there are any problems with sharing this information (KPIs)? If so, please explain what in the blank field below.	Ik voorzie hier geen probleem. Echter alleen wanneer de KPI anders uitvalt dan verwacht en je als bedrijf niet altijd de reden wilt delen met partners.	No, I do not see any problem with sharing KPIs
The COVID-19 pandemic has had a big impact on many supply chains worldwide. Please explain if the pandemic had any impact on your supply chain. If the answer is yes, please explain what this impact was. If possible, please go into detail about the effect on the whole supply chain. (For example; did you notice any signs of the ripple effect: This is when a disruption at one point in the supply chain moved (or 'rippled) through many parties within the supply chain.)	Ja, bij de inkoop van goederen die uit het buitenland komen. Bijvoorbeeld in India is nog steeds een lockdown gaande. Dus daar kan nog niet geproduceerd worden. Hierdoor krijgen wij de goederen pas later binnen of zelfs helemaal niet.	Yes, we have certainly seen the effects of the Covid pandemic. It started in January 2020, outstanding orders from china had slowed down considerably due to employees not going to work. At the moment we are mainly affected by price increases for electronics and absurd transport costs.
KPIs		
This question lists a set of KPIs that were found in the literature as information that can be shared within the supply chain that has a positive effect. Imagine you adapt information sharing as a proactive disruption risk management strategy within your supply chain. Proactive suggests that information is shared on a regular basis, before a disruptive event occurs. Please indicate what effect you believe it would have on your own business to share the mentioned KPI.		
[Inventory level]	Very positive impact	Somewhat postive impact
[Demand]	Very positive impact	Somewhat postive impact
[Production capacity]	Neutral impact	Very positive impact
[Sales/profit]	Very positive impact	Neutral impact
[Lead time]	Very positive impact	Somewhat postive impact
[Delivery time]	Very positive impact	Somewhat postive impact
[Service level]	Somewhat negative impact	Somewhat postive impact
[Order fulfilment]	Neutral impact	Neutral impact
If you have any remarks regarding this question please feel free to elaborate:	0	0
From your own experience, is there any other information that you believe can be shared between upstream and downstream supply chain partners with a positive effect? These could be KPIs that were not mentioned before, or something completely different.	X	Sharing information and forecasting sales certainly helps to reduce inventory, production effectiveness and cost savings.
Strategies		
Visibility: The impacts of a disruptive event can be mitigated by having full visibility along a supply chain of the raw materials, components and products and their locations. This requires a combined effort by partners along the supply chain. To what extent do you believe this is an effective strategy?	7	7
Please elaborate on your last answer about effectiveness of 'visiblity' as a disruption management strategy.	0	0
Collaborative forecasting: Planning the orders in collaboration with your supplier. If this strategy is properly executed, there should be less backorders. This strategy does require intense collaboration. To what extent do you believe this is an effective strategy?	9	7
Please elaborate on your last answer about effectiveness of 'collaborative forecasting' as a disruption management strategy.	0	0
Flexibility: The ability as a company to easily adapt to situations. Examples; back-up suppliers, back-up depots and transportation channels, inventory and capacity buffers, capacity expansion. This strategy is great for reacting to a disruptive event, but it takes time and money to manage back-up options. To what extent do you believe this is an effective strategy?	4	5
Please elaborate on your last answer about effectiveness of 'flexibility' as a disruption management strategy.	0	0
Digitalisation: Making supply chain information digitally available for supply chain partners. This strategy allows for almost instant data sharing when a digital system is in place, however security might be a concern when all your data is available online. To what extent do you believe this is an effective strategy?	10	3
Please elaborate on your last answer about effectiveness of 'digitalisation' as a disruption management strategy.	0	0

General	RESPONDENT 5	RESPONDENT 6
What industry does your company operate in?	0	0
What is the size of your company? (Amount of employees)	250+	26-100
What is your job description?	Business Proces Expert Logistics & Procurement for SAP application	Directeur
Many researchers have found that companies are not always willing to share information. Examples of shareable information (KPIs) are: inventory levels, delivery times, etc. How willing would you be (or are you already) to share such KPIs with your upstream & downstream supply chain partners?	9	7
Do you believe there are any problems with sharing this information (KPIs)? If so, please explain what in the blank field below.	If this is part of an SLA / commercial contract then it is common practice to share this with key customers (downstream). And same on the vendor side for raw material supply.	Het kan concurrentie gevoelig zijn
The COVID-19 pandemic has had a big impact on many supply chains worldwide. Please explain if the pandemic had any impact on your supply chain. If the answer is yes, please explain what this impact was. If possible, please go into detail about the effect on the whole supply chain. (For example; did you notice any signs of the ripple effect: This is when a disruption at one point in the supply chain moved (or 'rippled) through many parties within the supply chain.)	Our company has seen a strong growth especially in the pharma packaging segment. But also shortage on RM supply that is causing disruption in our planning, production and also supply to customers.	Niet zo zeer de covid pandemie heeft impact gehad maar het herstellen van de markt. daarbij zie je grote leveringsproblemen bij componenten leveranciers. Die hebben in verband met de wereldwijde pandemie waarschijnlijk productietechnische een lager voorcast ingeschat en dat bleek uiteindelijk niet zo te zijn. waardoor wereldwijd te weinig grondstoffen en componenten, hamstergedrag bij producenten waardoor het alleen maar erger wordt.
KPIs		
This question lists a set of KPIs that were found in the literature as information that can be shared within the supply chain that has a positive effect. Imagine you adapt information sharing as a proactive disruption risk management strategy within your supply chain. Proactive suggests that information is shared on a regular basis, before a disruptive event occurs. Please indicate what effect you believe it would have on your own business to share the mentioned KPI.		
[Inventory level]	Somewhat postive impact	Somewhat negative impact
[Demand]	Very positive impact	Neutral impact
[Production capacity]	Somewhat postive impact	Somewhat negative impact
[Sales/profit]	Neutral impact	Neutral impact
[Lead time]	Very positive impact	Somewhat negative impact
[Delivery time]	Somewhat postive impact	Very negative impact
[Service level]	Somewhat postive impact	Somewhat negative impact
[Order fulfilment]	Very positive impact	Somewhat negative impact
If you have any remarks regarding this question please feel free to elaborate:	KPI on forecast accuracy is very relevant and helps to understand the deviations between forecasted volume versus actual order placement or call off from stock.	0
From your own experience, is there any other information that you believe can be shared between upstream and downstream supply chain partners with a positive effect? These could be KPIs that were not mentioned before, or something completely different.	see my comments above.	Ik zie niet echt andere KPI, wel kun je meer kijken naar gelijkwaardige alternatieven.
Strategies		
Visibility: The impacts of a disruptive event can be mitigated by having full visibility along a supply chain of the raw materials, components and products and their locations. This requires a combined effort by partners along the supply chain. To what extent do you believe this is an effective strategy?	9	8
Please elaborate on your last answer about effectiveness of 'visiblity' as a disruption management strategy.	Visibility in the whole supply chain (with suppliers untill customers) is very helpfull but is also requiring a high level of willingness to cooperate.	Hierbij zou je inderdaad de kans krijgen om tijdig gelijkwaardige alternatieven te gaan zoeken.
Collaborative forecasting: Planning the orders in collaboration with your supplier. If this strategy is properly executed, there should be less backorders. This strategy does require intense collaboration. To what extent do you believe this is an effective strategy?	9	3
Please elaborate on your last answer about effectiveness of 'collaborative forecasting' as a disruption management strategy.	For sure this is very effective but if the sales forecast reliability is poor then the effectiveness is reduced.	Grote productiebedrijven zou dit prima werken, in ons bedrijf waar wij klant specifieke producten produceren niet.
Flexibility: The ability as a company to easily adapt to situations. Examples; back-up suppliers, back-up depots and transportation channels, inventory and capacity buffers, capacity expansion. This strategy is great for reacting to a disruptive event, but it takes time and money to manage back-up options. To what extent do you believe this is an effective strategy?	8	6
Please elaborate on your last answer about effectiveness of 'flexibility' as a disruption management strategy.	Flexibility in terms of machine capacity has its technical limitations. And also the same for the machine operators that can work to some extend in overtime but also has legal limitations.	Op zich een een strategie die goed zou kunnen werken echter er zou een probleem kunnen komen dat er een oude voorraad ontstaat die niet te hergebruiken is zogenaamd incourante voorraad.
Digitalisation: Making supply chain information digitally available for supply chain partners. This strategy allows for almost instant data sharing when a digital system is in place, however security might be a concern when all your data is available online. To what extent do you believe this is an effective strategy?	8	5
Please elaborate on your last answer about effectiveness of 'digitalisation' as a disruption management strategy.	0	Bij grote bedrijven zal dit waarschijnlijk een groter probleem zijn dan kleinere bedrijven maar heb hier geen ervaring mee.

General	RESPONDENT 7	RESPONDENT 8
What industry does your company operate in?	manufacturing of insulation material	Manufacturing of fabrics
What is the size of your company? (Amount of employees)	1-10	11-25
What is your job description?	Regional Director	Supply chain planner
Many researchers have found that companies are not always willing to share information. Examples of shareable information (KPIs) are: inventory levels, delivery times, etc. How willing would you be (or are you already) to share such KPIs with your upstream & downstream supply chain partners?	8	10
Do you believe there are any problems with sharing this information (KPIs)? If so, please explain what in the blank field below.	Low inventory levels can cause additional demand. In dutch "hamsteren".	No, I do not see any problem with sharing KPIs
The COVID-19 pandemic has had a big impact on many supply chains worldwide. Please explain if the pandemic had any impact on your supply chain. If the answer is yes, please explain what this impact was. If possible, please go into detail about the effect on the whole supply chain. (For example; did you notice any signs of the ripple effect: This is when a disruption at one point in the supply chain moved (or 'rippled) through many parties within the supply chain.)	Yes. Additional demand. Raw materials price up, availability down	Delays in material deliveries during the heights of the pandemic
KPIs		
This question lists a set of KPIs that were found in the literature as information that can be shared within the supply chain that has a positive effect. Imagine you adapt information sharing as a proactive disruption risk management strategy within your supply chain. Proactive suggests that information is shared on a regular basis, before a disruptive event occurs. Please indicate what effect you believe it would have on your own business to share the mentioned KPI.		
[Inventory level]	Neutral impact	Somewhat postive impact
[Demand]	Very positive impact	Very positive impact
[Production capacity]	Neutral impact	Somewhat postive impact
[Sales/profit]	Somewhat postive impact	Somewhat negative impact
[Lead time]	Very positive impact	Somewhat postive impact
[Delivery time]	Somewhat postive impact	Very positive impact
[Service level]	Very positive impact	Neutral impact
[Order fulfilment]	Very positive impact	Neutral impact
If you have any remarks regarding this question please feel free to elaborate:	0	0
From your own experience, is there any other information that you believe can be shared between upstream and downstream supply chain partners with a positive effect? These could be KPIs that were not mentioned before, or something completely different.	0	0
Strategies		
Visibility: The impacts of a disruptive event can be mitigated by having full visibility along a supply chain of the raw materials, components and products and their locations. This requires a combined effort by partners along the supply chain. To what extent do you believe this is an effective strategy?	6	7
Please elaborate on your last answer about effectiveness of 'visiblity' as a disruption management strategy.	Het delen van informatie is op papier een prima en effectieve strategie. Bij tekorten in de praktijk geldt echter vaak het principe van pakken wat je pakken kan. Dit lossen we niet op door betere informatie deling. Het hebben we langdurige partner relaties blijkt vaak wel effectief om in tijden van tekort toch goed geleverd te krijgen. Langerdurige partner relaties zijn vaak ook relaties waarin informatie goed gedeeld wordt. Gaat het toch weer hand in hand.	Full visibility might offer competing companies too much information about our operation, so it should be handled carefully.
Collaborative forecasting: Planning the orders in collaboration with your supplier. If this strategy is properly executed, there should be less backorders. This strategy does require intense collaboration. To what extent do you believe this is an effective strategy?	10	5
Please elaborate on your last answer about effectiveness of 'collaborative forecasting' as a disruption management strategy.	0	0
Flexibility: The ability as a company to easily adapt to situations. Examples; back-up suppliers, back-up depots and transportation channels, inventory and capacity buffers, capacity expansion. This strategy is great for reacting to a disruptive event, but it takes time and money to manage back-up options. To what extent do you believe this is an effective strategy?	8	6
Please elaborate on your last answer about effectiveness of 'flexibility' as a disruption management strategy.	0	Can be costly and for that reason might not apply for us as a smaller company
Digitalisation: Making supply chain information digitally available for supply chain partners. This strategy allows for almost instant data sharing when a digital system is in place, however security might be a concern when all your data is available online. To what extent do you believe this is an effective strategy?	9	7
Please elaborate on your last answer about effectiveness of 'digitalisation' as a disruption management strategy.	0	0