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Supply chain Resilience and its most suited elements to decrease energy price spike risks.

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Abstract

Supply chains are becoming increasingly vulnerable to supply chain disruptions and the risk of these disruptions is becoming higher. Therefore, an increase in interest in Supply-Chain resilience and how it can decrease risk in supply chains is seen in literature. This research tries to examine what the most suited SCRES elements are to decrease the risks of an increase in the energy price, as was experienced in 2021-2022. This disruption is truly relevant and the combination of, for instance the influence by other disruptions, such as the war in Ukraine and Covid-19, the global impact, the increased political interest, and the influence on other triggers for supply chain disruption, makes it very complex. Certain SCRES elements may be effective in influencing the main risks, which are an increase in product price and a decrease in material availability, which is researched in this paper. This research is set up as a case study combined with a literature review. In the case study, three strategic buyers and fifteen suppliers of the case company will be interviewed. The findings show that Visibility, Collaboration, Market Position and Social Capital are the most suited to decrease the stated risks. Where Visibility was described to reduce product price, Collaboration to increase material availability and Market Position and Social Capital, to have a positive influence on both. Market Position and Social Capital additionally also were found to have a positive influence on the implementation of other SCRES elements. Next to that, Visibility was described to have a positive influence on Flexibility, Agility and Collaboration. To conclude, Redundancy and Supplier Flexibility showed to have a different role than expected. They both only had a positive influence when implemented before the disruption occurs and should therefore be seen as pro-active strategies.

Keywords

Supply-chain resilience, Supply chain disruption, Supply chain risk, Energy price disruption, Visibility, Collaboration, Market Position, Social Capital

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1. INTRODUCTION

Supply uncertainty is something that has been bothering supply chain managers for decades now, but supply chain disruptions are getting more frequent and more severe through the years (Katsaliaki et al., 2021, p. 965). Supply chains that provide raw materials for manufacturing companies/supply chains, will be increasingly vulnerable as a result of the increase of worldwide political instability, health crises, and natural disasters (Althaf & Babbitt, 2021, p. 1). Examples of these phenomena we have seen in the past years are the covid crisis, the Russian invasion of Ukraine (Yagi & Managi, 2023, p. 680) and the increase in floods and landslides (Min, 2022, p. 14). Supply chains are also more often exposed to increased risks, due to increased globalization, supply base reduction, and more volatile environments (Craighead et al., 2007, p. 151; Shekarian & Mellat Parast, 2021, p. 427). The risk of supply chain disruptions also is expected to be higher now than before, as the implementation of certain supply chain practices, such as lean production and outsourcing, decrease the buffer inventory within supply chains (Wu et al., 2011, p. 159). In literature, the definition supply chain risk, supply chain disruption risk and supply chain disruption are all used for somewhat the same phenomenon. Supply chain risk is defined by Peck (2006, p. 132), as "anything that presents a risk in information, material and product flows from original suppliers to the delivery of the final product to the ultimate end-user".

The energy price spike is one of the most recent supply chain disruptions that occurred which makes it very relevant and it is a complex disruption, as it is influenced by/influences a lot of different aspects (Ozili & Ozen, 2023, pp. 1-3). As a result of the Russian invasion of Ukraine, the energy prices in Europe have spiked (Ozili, 2022, p. 13). This is because the EU heavily relies on Russia for its oil and gas, as 40% of all the gas used in Europe is bought from Russia (Astrov et al., 2022, p. 350), and 34% of all the electricity in Europe is generated by using gas (Haddad, 2022, p. 1). Other causes described by literature are the halt in global trading and the sharp increase in energy demand afterwards, caused by the COVID-19 pandemic and resulting supply chain disruptions (Ozili & Ozen, 2023, pp. 2-3), increased interconnectivity of natural gas markets, and evidence of energy price instability as the world shifts to renewable energy sources (Berahab, 2022, p. 2). The focus on implementing and finding renewable energy sources also has high political interest due to the global climate crisis, which results in energy prices also being dependent of political influences (Bijnens et al., 2022, p. 38). Next to that, it is a disruption that affected companies all over the world (Ozili & Ozen, 2023, p. 16), which means it influences complete

supply-chains instead of only nodes. It also has an effect on other triggers for supply chain disruptions, such as force majeures (DuHadway et al., 2019, p. 184) and logistics in supply chains (Medina-Serrano et al., 2022, p. 4659). Force majeures can be initiated by a spike in the energy price, as such extreme increases in costs could not have been foreseen by suppliers. The price of logistics also increases highly as it is dependent on energy for fuel (Cheng et al., 2023, p. 1). As a result of all these influences, energy has become a complex and unpredictable commodity input influenced by multiple factors and rules (Mulhall & Bryson, 2014, p. 328). The higher and more volatile industrial prices of energy cause individual firms and the supply chains they are in to have higher technical price risks, which makes the management of this input harder and more important (Mulhall & Bryson, 2014, p. 327).

A focus has emerged on the fact that energy influences and can have consequences on the competitiveness of supply chains and firms within these supply chains (Ali Ahmed et al., 2012, p. 454; Froggatt & Lahn, 2010, p. 26). Energy prices have been shown to have a huge impact on the production of goods and services within supply chains and can have a huge impact on the security of output of these supply chains. The cost of energy is an important factor in the total production cost of manufacturing companies (Bijnens et al., 2022, p. 38) and therefore a great influence on the output a manufacturing company delivers. In recent years, energy prices spiked so much that some manufacturing companies even had to stop producing because of costs that were too high. This shows that higher energy prices can cause disruptions that may spread easily through a complete supply chain (Dolgui et al., 2018, p. 415). For buying firms the main disruption risk is that they will not get the products delivered they need to produce their own goods. Another supply chain risk of energy price volatility is the expected low visibility on energy prices within supply chains (Mulhall & Bryson, 2014, p. 332). It is highly likely, that supply chain participants do not know which energy supplier their supply chain partners have and how much they pay for it, which creates a risk, as a lower visibility, increases the harm a disruption can do (Scholten & Schilder, 2015, pp. 472-473). This shows that as described by (Saarinen, 2023, p. 1), companies should change their strategies according to the fact of a higher than expected energy cost and the risks that occur, also considering suppliers problems.

As a result of the extra uncertainty caused by the risks described before, whole supply chains will be affected, which makes research on supply chain resilience (Ali et al., 2017; Shekarian & Mellat Parast, 2021) the most appropriate to use. Another reason that makes supply chain resilience

appropriate to use, is that one of the elements of supply chain resilience, namely visibility (Scholten & Schilder, 2015, pp. 472-473) is expected to be low when looking at the risk of energy price volatility. A description is that supply chain resilience "reduces the impact of disruptions by identifying strategies that allow a supply chain to react to a disruption while recovering to its original functional state or better" (Shekarian & Mellat Parast, 2021, p. 428). Different managerial practices in supply chain resilience are described to decrease different types of risks by gaining elements of SCRES, of which we assume that some may be suited to decrease the risk caused by energy price volatility. Some examples of SCRES elements found in literature are Visibility, Collaboration, Agility, Contingency Planning and Market Position and some examples of practices are multiple sourcing to increase flexibility and information sharing to increase visibility (Ali et al., 2017, pp. 27-28). Because of the things described above, the energy price as a disruption is a good disruption to research regarding the usefulness of SCRES and its elements. Also, because it currently is a very relevant topic as it is one of the most recent supply-chain disruptions that occurred, which makes it very researchable at the case company. Next to that was stated by (Ingram et al., 2023, p. 11), that creating resilience to adapt to the energy crisis on an organizational level will most likely require a different approach and no literature has offered a unifying theory on this. Looking at all the literature and theory stated before, two clear research gaps can be addressed:

1. Energy price volatility is a complex supply chain disruption as is described in the introduction, because of the combination of the causes, characteristics, and outcomes of the risks. Due to this, the influence of SCRES elements and how they need to be implemented might differ. Next to that, currently not much empirical research exists on the practical impact of a higher energy price and the disruption it creates on supply-chains, why it is now relevant to research.
2. A lot of research on supply chain resilience (Ali et al., 2017; Rahman et al., 2022; Scholten et al., 2014; Shekarian & Mellat Parast, 2021) exists, but given the characteristics and outcomes of the risk of energy price volatility (ex. low visibility), more attention should be paid to certain managerial practices to increase resilience and how they can be used in a different way to decrease the risk of energy price volatility. About this not enough is known yet, as no empirical research currently exists on how the risks of a spike in the energy price can be reduced by implementing supply chain resilience on an organizational level.

The objective of this research is to get a clear understanding of how to cope with complex supply chain disruptions by implementing supply chain resilience practices. This is done by researching

how to decrease the specific kind of disruption risk of the energy price increase by using the most suitable managerial practices and therefore answering the research question: *Which elements of supply chain resilience are most suited to decrease the risks caused by energy price volatility at suppliers of buying firms?*

The answer to this question will be found by extensively reviewing the existing literature on supply chain disruptions, energy dependence, energy price volatility and supply chain resilience from the perspective of a buying firm. This review will be combined with an empirical case study in a manufacturing supply chain, to combine the found results with practical knowledge and findings, so that this research can contribute both academically and practically. This is done to dissolve the research gap of how implementing supply chain resilience can contribute to practically decrease the supply chain risk of volatile energy prices and describe how complex the energy price is as a disruption. A description will be provided of how buying firms can implement supply chain resilience to decrease the risk of volatile energy prices in their supply chains.

The remaining part of this paper has the following structure. In the next chapter a clear theoretical framework will be conducted by thoroughly reviewing the literature of all supply chain disruption risks in general, energy dependence risk specifically and supply chain resilience. In the third part the methodology of the research is explained. After that the results are summed up and explained, to be able to draw a conclusion in part five. To conclude the results will be discussed by describing the theoretical and academical implications and recommend for future research.

2. LITERATURE REVIEW

2.1 Supply chain risk

2.1.1 Supply chain (disruption) risk explained.

In this part is described what different supply chain (disruption) risks can be found in literature. The risks that are found will be discussed thoroughly to be able to assess what risks are influenced by volatile energy prices.

Supply chain risk is described by Tummala and Schoenherr (2011, p. 474) as; "an event that adversely affects supply chain operations and hence its desired performance measures, such as chain-wide service levels and responsiveness as well as cost". Ho et al. (2015, p. 5035) define supply chain risk as "the likelihood and impact of unexpected macro and/ or micro level events or conditions that adversely influence any part of a supply chain leading to operational, tactical, or strategic level failures or irregularities". Looking at the definitions of supply chain risks described, all agree on them having negative effects on supply-chains, as unexpected disturbances in product or information flow or unexpected costs occur. But in this research we focus on the definition of (Shekarian & Mellat Parast, 2021, p. 428), "potential deviations in incoming supplies and potential disturbances to the flow of products and information from within the network of supply", because their research also specifically focuses on supply chain resilience.

In literature a lot of specific triggers of supply chain (disruption) risks are mentioned, such as product recalls (Lawson et al., 2019, p. 1077), cultural differences (misunderstanding between parties), legal uncertainty, transport infrastructure failure, (Durach et al., 2017, p. 844), unexpected material, financial, or informational risks (Brito & Jacinto, 2020, pp. 79-80), natural disasters, wars, single sources of supply (Tummala & Schoenherr, 2011, p. 475), force majeure contract breaches (DuHadway et al., 2019, p. 184), logistics, climate change (Medina-Serrano et al., 2022, p. 4659) and quality uncertainty (Tse, 2012, p. 25). What links all the triggers is that they have negative outcomes, but all on different scales. For instance, wars have a very big scale of disruption, where quality uncertainty is only little. In this research these will not be focused on but might be revert to.

In literature a lot of different supply chain risk classifications are discussed. Shekarian and Mellat Parast (2021, pp. 429-431) conducted a framework to categorize the five sources of supply chain (disruption) risk. The sources of risk are 1) demand risk, 2) supply risk, 3) process risk, 4) control risk (network risk), and 5) environmental risk. Examples of the risks in these categories can be seen

in Figure 1 below. Another example is the classification of Loach (2000), who classifies supply chain risks in 1) external factors (environmental, competitors, political etc.), 2) internal factors (processes and operations) and 3) decision factors (wrong decisions, wrong execution etc.). In the research of Sato et al. (2020), a distinction is made between demand, quality and logistic uncertainty. Alikhani et al. (2023, p. 1), describe that there are three groups, namely: natural, man-made, and pandemic-oriented. They say that man-made risks are easier to manage, and natural risks are random and hard to estimate. The pandemic-oriented risks are described to be different in some aspects of the man-made risks. 1) they last longer, and the scale of their impact is unpredictable, 2) with pandemics, different nodes within the supply-chain will shut down, and 3) with pandemics, there will be disruptions in the supply, demand, and/or process, which will cause a ripple effect (sometimes forward, sometimes backwards). This ripple effect can result in masking the origin and begin of these disruptions and therefore increase the risk it brings (Dolgui et al., 2018, pp. 417-418). One thing most have in common, is that is differentiated between internal and external risks, where only Alikhani et al. (2023, p. 1) differentiates them on impact and size. In this research not an explicit classification is used.

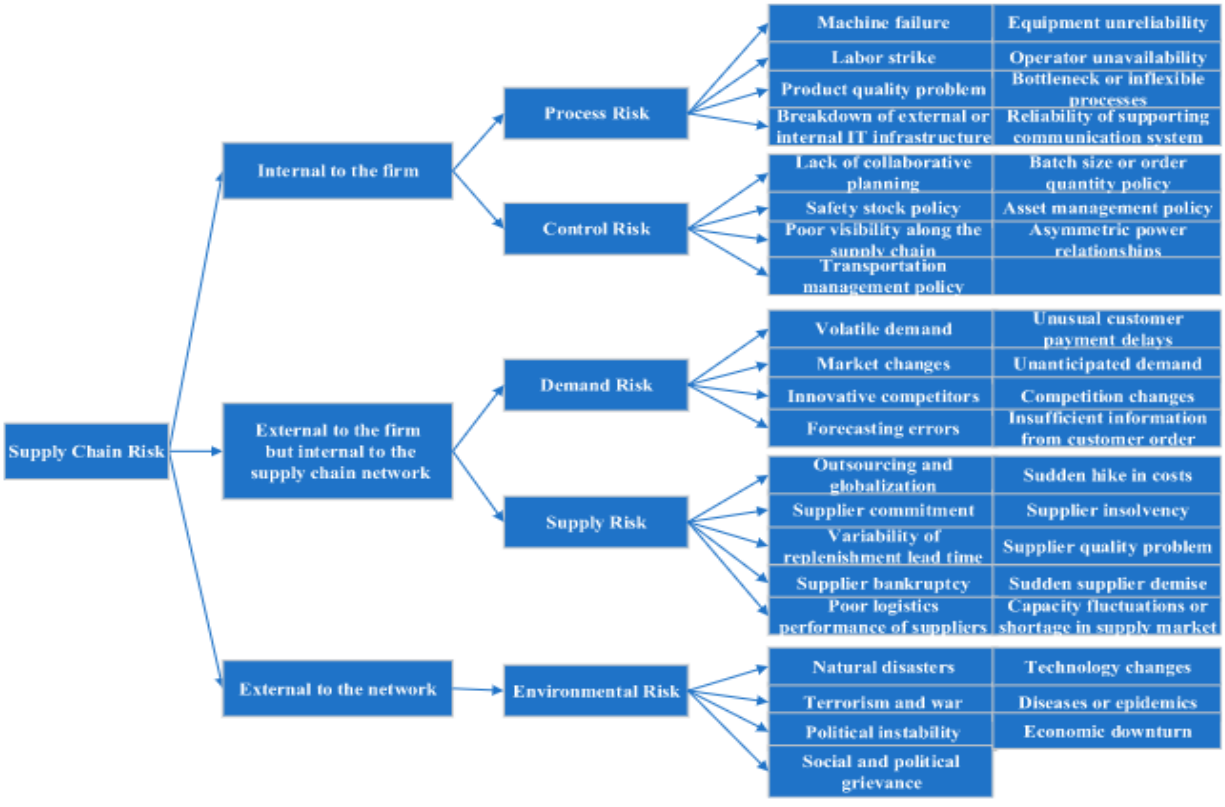

Figure 1: Table of Supply chain risk and it categories (Shekarian & Mellat Parast, 2021, p. 430)

In the next part of this chapter, a clear light will be shed on what can be found in the literature about the dependency on energy in supply chains and manufacturing firms. By doing this, the risk that dependency on energy brings can be outlined, which will result in being able to explain what supply chain risks are influenced because of energy dependence.

2.1.2 Energy Dependence Risk

In this part, the fact that being dependent on energy creates a risk of not being able to produce or distribute their products anymore will be described, to make clear what the risk is and why it is important to focus on.

According to Edelstein and Kilian (2007, p. 6), manufacturing firms have a couple of main goods they buy to be able to provide for their energy needs, which are gasoline, heating oil, electricity and natural gas (little crude oil). This results in them saying that: "There is reason to believe that crude oil prices do not reflect the energy costs faced by firms". Bardazzi et al. (2015, p. 176) say that the main used energy sources by manufacturing firms are natural gas and electricity, which also account for the highest cost. In this paper the focus is on the cost of energy for supplier firms and how this imposes risk for the buying firm, therefore the focus will be on the price to fulfill energy needs of manufacturing firms. As energy is one of the main sources to produce and handle products, the risks it brings for manufacturing companies are high. Adding to this that the low cost of energy is not guaranteed anymore, means that the need for energy and the performance of a firm cannot be seen as two independent things and the dependency on energy for firm performance should be focused on in supply chain management (Halldórsson & Kovács, 2010, p. 6).

The performance of logistics in supply chains is also influenced by the rising costs of energy (Edelstein & Kilian, 2007, p. 6). As a result of environmental considerations and carbon footprints and electrification of transport, the price of electricity is becoming more influential in logistics, as more transport will be done by vehicles powered with electricity. Therefore, firms that are in supply chains where a lot of transport is happening may find themselves in difficult situations when energy prices are becoming high at a certain moment, which may result in them not being able to produce their own good or transport their goods downstream. Another part of logistics that also is very dependent on the price of energy is the warehousing and storage of components or finished products, as these warehouses need energy for heating and light (Halldórsson & Kovács, 2010, p. 8). Manufacturing firms may therefore consider decreasing the amount of stock they keep, when

prices are volatile, to decrease the risk of having very high costs, just because they have big warehouses to store components and finished products.

Another risk opposed by Christopher and Holweg (2017, p. 10) is the fact that energy dependence is not as widely spoken about and given as much attention to as turbulence related to other supply materials. From their research they concluded that energy costs are mentioned way less than they expected, when executives in purchasing are asked what factors cause the most turbulence in their firms' supply chain. This shows that energy dependence risk does not yet get the attention it needs to get, as it exposes supply chains to high level of risks.

The overall described energy dependence risk therefore can be described as the risk that prices get so volatile\high, that firms through one of the described results, are not able to produce their product anymore or get their product downstream. In the context of this research, the risk therefore is that the buyer firm does not get their supply, due to volatile energy prices resulting in supply disruptions.

2.1.3 Risks triggered by volatile energy prices.

In this part the discussed supply chain risks and supply chain disruption risks will be linked to the risk of volatile energy prices. It will show that it is connected to a lot of parts of a supply chain and therefore is very complicated to study. This will only be done to create clarity on the complexity of energy prices, and the risks and disruption it is linked to (see Table 1). In the remaining part of this research, the focus will only be on the main risks described by the case company, which are price increases of products and unavailability of products.

Risk Categories	Source	Could it be influenced by volatile energy prices	Does it influence volatile energy prices
Transport infrastructure failure	(Durach et al., 2017)	✓	
Unexpected financial risk	(Brito & Jacinto, 2020)	✓	
Unexpected informational risk	(Brito & Jacinto, 2020)		✓
Natural disasters	(Tummala & Schoenherr, 2011)		✓
Wars	(Tummala & Schoenherr, 2011)		✓
Single source of supply	(Tummala & Schoenherr, 2011)	✓	
Force majeure contract breaches	(DuHadway et al., 2019)	✓	
Climate change	(Medina-Serrano et al., 2022)		✓
Logistic risks	(Medina-Serrano et al., 2022)	✓	

Table 1: Table with factors that are influenced by/influence energy price volatility.

Transport infrastructure is something that is influenced by and will be more influenced by energy price volatility in the coming years, as electrical vehicles are more and more included into the fleets of a lot of companies (Pelletier et al., 2016, p. 4). The inclusion of electric vehicles in logistic fleets, means that firms have to consider the electricity price curves for charging the vehicles (Deng et al., 2022, p. 2). Electrical transport of goods and supplies will become more important because of the renewable energy discussion and the stricter governmental regulations on carbon emissions in supply chains (Siller, 2019). Of course transport infrastructure is currently highly dependent on the oil prices (F Gross et al., 2012, p. 150). Due to this combination, the risk of electricity price volatility will become higher. A volatile/high electricity price can result in the cost being too high for the supplier to deliver their products and therefore not being able to get your products as a buying firm, as transportations cost accounts for over 30% of the total cost of goods (Rahmanzadeh Tootkaleh et al., 2014, p. 891). Looking at logistics the risk is almost the same, but here the warehousing of goods should also be taken into consideration. This is because warehouses need electricity and gas for heating and light (Halldórsson & Kovács, 2010, p. 8), which makes firms with big warehouses even more vulnerable for volatile energy prices.

One of the two main risks focused on in this research and influenced by a volatile or high energy price is that it brings financial risk to every firm that is dependent on energy for its production. This is because of the price of production being absurdly high in an instance or paying extensively more for products needed for production. Natural disasters and wars are things than can influence the price of energy, as can be seen looking at the price spike of electricity and gas after Russia invaded Ukraine (Ozili, 2022, p. 13). The risk of a single source of supply is increased by energy price volatility, as the chance of a supply disruption increases due to the different factors that are influenced by energy price volatility. When energy prices become very high, force majeure contract breaches could happen more often, as an unexpectedly high energy price brings a production firm in an extremely difficult situation, they could not have foreseen. This means that they could legally break the contract and are allowed to not deliver. Which results in a supply disruption at the buyer's firm. Climate change and the whole energy renewal around it is another thing that is influencing the energy price and its volatility (Berahab, 2022, p. 2), because it brings other sources of energy in the field, limits the use of oil and gas and increases prices of energy.

In this chapter a lot of risks are described, which are connected to energy prices within supply chains. As a case study will be conducted, the focus in this research will be on the risks that are

described by the company of the case study to be the most influencing. These are the rising prices of products due to a higher energy price and the unavailability of products due to the discontinuation of production because of higher cost for energy. Also, when looking at the famous Kraljic Matrix, described by (Kraljic, 1983), the two main dimensions to focus on when looking at purchasing products, are supply risk and profit impact (Caniels & Gelderman, 2005, p. 143). Supply risk can be linked to the unavailability of products and profit impact to the higher prices of products, therefore in this research, the higher/more volatile energy price, is influencing both the supply risk as the profit impact. This shows that also in literature these are important risks in supply chains to consider when you are, from a buyer's perspective actively trying to decrease risks in a supply chain.

As described in the introduction, supply chain resilience is described in literature to be one of the solutions to decrease the risk of supply chain disruptions. In the next part SCRES will be described and from a buying firm's perspective will be looked at how it could be helpful when decreasing the supply chain disruption risk of high/volatile energy prices.

2.2 Supply chain resilience and risk assessment

In the first part of this chapter, an enumeration on what different strategies to become more resilient can be found in literature, and the framework of (Ali et al., 2017, p. 28), which will be focused on in this research, will be showed. After that, in the second part, all the elements of SCRES and its managerial practices are discussed. This will give a clear overview on the different SCRES elements that can be implemented to decrease the risk focused on in this research.

2.2.1 Supply chain resilience strategies and its elements

In this chapter, some of the strategies to mitigate supply chain risks by becoming more resilient as a company, described in literature will be summed up, to create a clear image on what strategies can be found.

In the last couple of years, SCRES is a widely researched and talked about topic. A lot of different definitions are used in a lot of different research, and they all seem to use resilience in a different context. To show the interest around SCRES, a couple of definitions will be compared: "supply chain resilience is a risk management initiative that enables an organization to respond rapidly to uncertain changes and disruptions in the supply chain" (Jain et al., 2017, p. 6779), "Resilience is referred to as the ability of supply chains to cope with unexpected disturbances" (Carvalho et al.,

2012, p. 49), and "the ability of a system to return to its original state or move to a new, more desirable state after being disturbed" (Christopher & Peck, 2004, p. 2). As can be seen, the focus of all definitions is on supply-chains reacting to abrupt changes and not suffering from it. In this research we will focus on the definition given by Christopher and Peck (2004), as we focus on how a buying firm can increase its competitive advantage, by implementing SCRES practices to decrease the risks caused by energy price volatility.

In literature there are different approaches on how strategies that enhance resilience are classified. There are three main characteristics on which they are classified, namely time, are the strategies implemented before (proactive/readiness), during (concurrent/response) or after (reactive/ recovery) the disruption (Ali et al., 2017; Ponomarov & Holcomb, 2009; Rahman et al., 2022), whether they support robustness and/or agility (Wieland & Wallenburg, 2013), and the actors involved, is the strategy implemented by a single firm or collaboratively (Scholten & Schilder, 2015). In Figure 2 a mapping framework is shown of the classification made by (Ali et al., 2017, p. 28), which includes different elements of SCRES. In literature there is not a clear consensus on how the "Elements of resilience strategies" (Ali et al., 2017) are described, some researchers also describe them as "Enablers of SCRES" (Soni et al., 2014), or "antecedents of SCRES" (Ponomarov & Holcomb, 2009). Also the different hierarchical levels differ per research, as some use "managerial practices" as what companies have to do, to gain the element of for instance flexibility (Ali et al., 2017), but others mention increasing flexibility as a SCRES strategy (Ambulkar et al., 2015). To be able to describe it as clear as possible, we will in this research focus on the mapping framework of (Ali et al., 2017, p. 28), as this gives a clear overview. This means that we will also focus on the hierarchical levels they use, which refers to our research question, in which we are searching for the best managerial practices to implement in our case.

Which practices of resilience can best be implemented to decrease the disruption risk caused by energy price volatility at suppliers according to literature, is discussed in the next part of this chapter. First, we will discuss the different elements and how they can help firms to decrease risk.

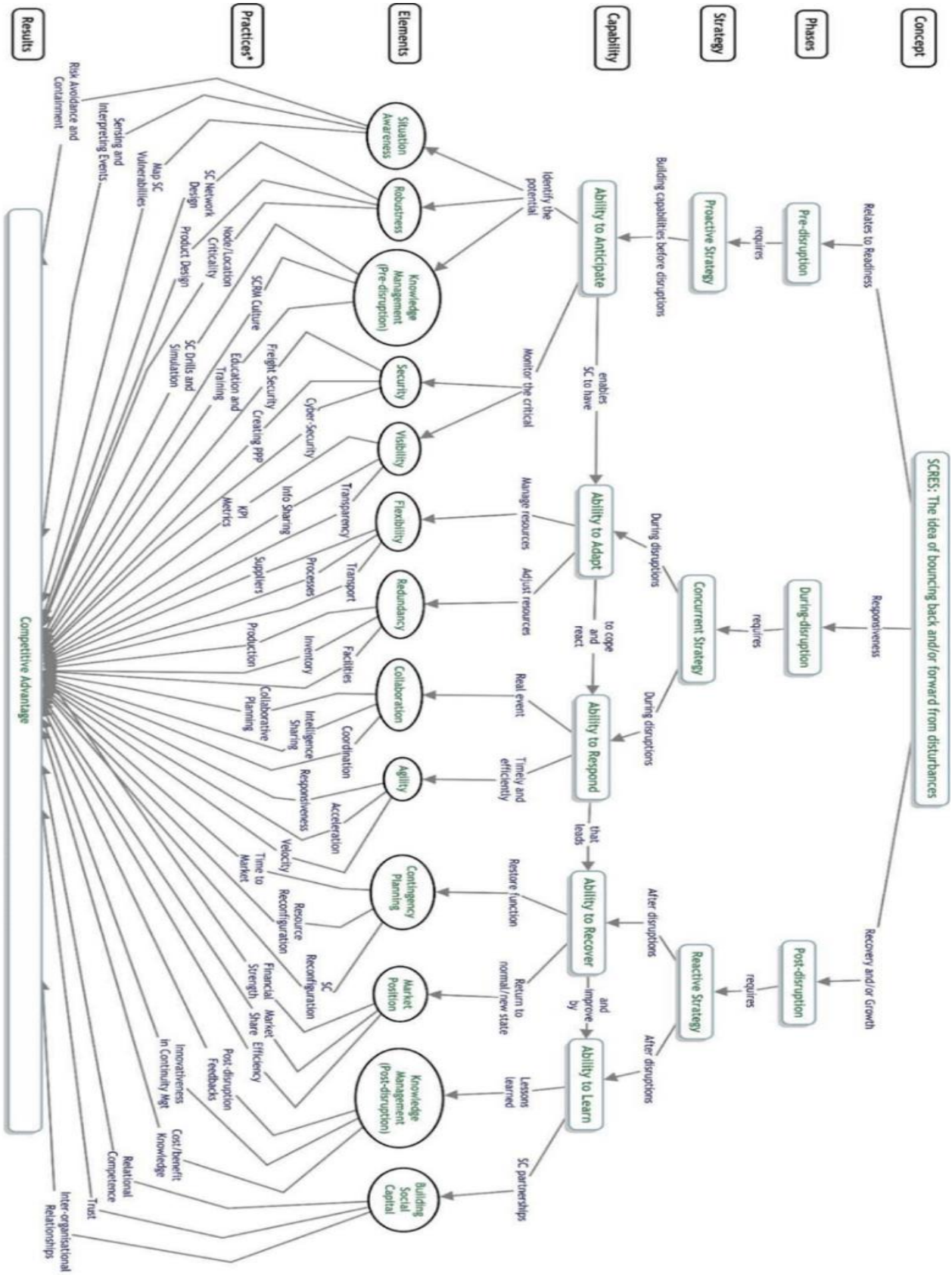

Figure 2: SCRES concept mapping framework (Ali et al., 2017, p. 28)

As can be seen in Figure 2, a lot of different managerial practices can be implemented to gain the elements of resilience. There are 13 different elements mentioned that are all linked to the proactive, concurrent, or reactive strategies. A proactive strategy are practices being implemented before the disruptions takes place and involves planning to decrease the probability that a disruption will occur (Thun et al., 2011, p. 5514) and/or to decrease the impact of the disruption when it still happens (Knemeyer et al., 2009, pp. 141-142). An example of this is becoming more robust through product design (Ali et al., 2017, p. 28). Concurrent strategies are practices being implemented during the disruption. They are focused on knowing what to do when a disruption takes place (Ivanov et al., 2014, p. 2159) and focus on how to continue the business of the company (Scholten et al., 2019, p. 437). At last, reactive strategies are practices being implemented after the disruption and focus on recovering from the disruption (Ali et al., 2017, p. 21). The practices focus on getting more adaptive and restorative capacity (Hosseini et al., 2019, p. 298).

To be able to compare the risks that are created by energy price volatility to how resilience strategies and its practices help to decrease disruption risk, we need to have a clear understanding of what the different resilience elements are and how they help to decrease risks. This will help us to find the best suitable practices to use for the specific risks focused on in this research. Therefore, the different resilience elements described by Ali et al. (2017, pp. 27-28) will be discussed below. First, the elements of proactive strategies are described, which has 5 elements. The first one is Situation Awareness, which focuses on events to sense and interpret possible disruption causes, by understanding of supply chain vulnerabilities and planning to decrease them (Ali et al., 2017, p. 25). Robustness is the second element, which is also described in literature as a self-standing resilience strategy (Hasani & Khosrojerdi, 2016). Robustness focuses on resisting change, by being prepared and able to anticipate to disruptions that may occur (Wieland & Wallenburg, 2013, p. 312) and keep operating during a disruption (Tang, 2006, p. 36). This can be done by designing supply chains in a way that more inventory is held (Wieland & Wallenburg, 2012, p. 891). The third element of proactivity is pre-disruption knowledge management, this focuses on having the knowledge on the informational and physical structure within the supply chain (Ponomarov & Holcomb, 2009, p. 127). It is focused on creating an SCRES culture (Christopher & Peck, 2004, p. 7), and education and training (Jüttner & Maklan, 2011, p. 254) to enhance the understanding of the supply chain of all members of the firm, which increases SCRES (Blackhurst et al., 2011, p. 380). Security is the next element, and should identify suspicious elements and identify security

breaches that threaten information systems, which can cause damage to for instance freight management (Manuj & Mentzer, 2008, pp. 198, 210). The last one is Visibility and focuses on increasing the knowledge and status of the operations and environment of a company (Fiksel et al., 2014, p. 84). Upstream and downstream visibility should be enhanced by increasing exchange of information between important entities of the supply chain as it is described by Christopher and Peck (2004, p. 6) to be too low in a lot of supply chains.

For the concurrent strategy, Ali et al. (2017, p. 28), included 4 different elements. The first one, Flexibility is the second most studied element from the framework of (Ali et al., 2017, p. 28). Flexibility consists of practices that build capabilities to respond to changes and disruptions quickly, but it also has benefits in times of normal business (Sheffi & Rice Jr, 2005, pp. 45-47). It helps to change to be able to function in the disruption instead of withstanding it (Wallace & Choi, 2011, p. 285) by having a flexible strategy for supply, demand and process management (Tang & Tomlin, 2008, p. 15). Redundancy is the second element, and is focused on "the strategic disposition of additional capacity and\or inventory" (Christopher & Peck, 2004, p. 8) to defend firms against disruptions (Rice & Caniato, 2003, p. 26). The third element is collaboration. Collaboration is in literature described as being able to reduce risks and react to disruption by working together and communicating with other actors in the supply-chain (Christopher & Peck, 2004, p. 9) in the direction of shared objectives (Cao et al., 2010, p. 6614). Better collaboration in the supply-chain can also be a way to share risks and therefore function better in risky situations (Um & Han, 2021, p. 245). Agility is the last element of a concurrent strategy and the ability to respond. It is focused on how fast can be reacted to change in the supply-chain (Wieland & Wallenburg, 2012, p. 890), which enables a firm to decrease the impact of the disruption (Ali et al., 2017, p. 27; Christopher & Peck, 2004, p. 9). Higher agility makes sure that a firm is always prepared to response fast to disruptions (Braunscheidel & Suresh, 2009, p. 120) by having a responsive process and high velocity (Scholten et al., 2014, pp. 215, 221).

The last strategy is the reactive or recovery strategy that includes practices to recover and learn from disruptions and the risks these bring after they occurred (Ali et al., 2017, p. 27). This includes four elements, with the first being contingency planning, which can enable a firm to recover from the disruption by looking at which actions they can take in this phase (Ali et al., 2017, p. 27). An example is reconsidering back-ups and alternative supply chain networks (Hosseini et al., 2019, p. 300). It is mostly about measuring contingency plans, so that they are able to restore the supply

chain if needed, considering logistics and inventory (Gong et al., 2014, p. 105). Another element that increase the ability of firms to recover from disruptions is market position (Ali et al., 2017, p. 27) and this is partly because of the financial strength it brings (Fiksel et al., 2014, p. 85). Another reason that it increases firm resilience is because of the higher margins the firm can maintain on its products, which enables investment in resilience (Sheffi & Rice Jr, 2005, p. 44). The third element is post-disruption knowledge management (Ali et al., 2017, p. 27). This element is about learning from the disruption that has just occurred (Ponomarov & Holcomb, 2009, p. 127). The last element of reactivity is building social capital, which is mainly focused on the relationships within the supply chain, in which the ability to learn from each other increases when they come closer in the relationship (Ali et al., 2017, p. 27). Higher trust in these relationships can increase the social capital aspect like information sharing and resource sharing, which can be important to recover from disruption (Seville et al., 2015, p. 10).

All the different elements of the resilience strategies described by Ali et al. (2017), are hereby discussed, which enables us to look at the managerial practices and link them to the risks caused by a high/volatile energy price. In the next subchapter, a deeper dive will be made into the different managerial practices of the resilience elements described by Ali et al. (2017).

2.2.2 Resilience practices for electricity price volatility

In this chapter the description of all elements of SCRES will be combined with what kind of managerial practices they include and how these could help to mitigate the risks focused on in this research. Table 2 will show the SCRES elements and its managerial practices.

Elements	Managerial practices	(Optional explanation)	Source
Situation awareness	Risk analysis / Risk assessment	Brainstorm sessions (Raj Sinha et al., 2004) (158)	(DuHadway et al., 2019; Norrman & Jansson, 2004; Raj Sinha et al., 2004; Sáenz & Revilla, 2014)
	Identifying/detecting risk		(DuHadway et al., 2019; Priya Datta et al., 2007)
	Mapping SC vulnerabilities		(Sáenz & Revilla, 2014) (Melnyk et al., 2010)
	Creating risk awareness		(Sáenz & Revilla, 2014)
Robustness	Supply chain design		(Wieland & Wallenburg, 2013) (Wieland & Wallenburg, 2013) (Tang, 2006) (Khan et al., 2012)
	Product Design		(Khan et al., 2012)
	Postponement		(Tang, 2006)
	Make-and-buy		(Tang, 2006)
Knowledge management	Creating a SCRES culture		(Christopher & Peck, 2004)

(pre-disruption)			
	SCRES Education and training	Supply chain drills, simulations, and exercises	(Jüttner & Maklan, 2011) (Rice & Caniato, 2003)
Security	Identification of suspicious security elements		(Manuj & Mentzer, 2008)
	Create a clear and formal security strategy		(Rice & Caniato, 2003)
Visibility	Information Sharing		(Jüttner & Maklan, 2011; Kache & Seuring, 2014; Kleindorfer & Saad, 2005; Lee, 2002; Simatupang & Sridharan, 2008)
	Create mutual KPI's	Annual target costs, cost saving goals, risk management process, Lead times	(Ambulkar et al., 2015; Daugherty et al., 2006) (Jüttner & Maklan, 2011)
	Transparency (Digital)	Inventory flow monitoring, outage identification, Inventory management	(de Farias et al., 2022) (Stecke & Kumar, 2009)
	Integrated information systems		(Melnyk et al., 2010)
Flexibility	Modularity of process and product		(Ivanov et al., 2014; Kleindorfer & Saad, 2005)
	Supplier flexibility		(Azadegan et al., 2021; Hosseini et al., 2019; Ivanov et al., 2014; Lee, 2002; Shekarian & Mellat Parast, 2021; Sreedevi & Saranga, 2017; Tang & Tomlin, 2008)
	Flexible manufacturing facilities		(Scholten & Schilder, 2015; Sheffi & Rice Jr, 2005)
	Manufacturing flexibility	Mix, volume, and product modification flexibility	(Sreedevi & Saranga, 2017)(335)
	Distribution/ logistics flexibility		(Sreedevi & Saranga, 2017; Wallace & Choi, 2011)
	Flexible supply contracts	Ability to change supply quantity	(Kesen et al., 2010; Sreedevi & Saranga, 2017; Tang & Tomlin, 2008) (Azadegan et al., 2021)
	Effective supplier relationship management	For example, joint decision making with key suppliers	(Swafford et al., 2006)
Redundancy	Maintaining excess capacity		(Rice & Caniato, 2003)
	Maintaining safety stock		(Sheffi & Rice Jr, 2005)
Collaboration	Intelligence sharing		(Ali et al., 2017; Cao et al., 2010; Scholten & Schilder, 2015)
	Incentive alignment (risk and reward sharing)		(Jain et al., 2017; Kache & Seuring, 2014; Mentzer et al., 2001; Pettit & Beresford, 2009)(461-461)(Cao et al., 2010; Jüttner & Maklan, 2011; Simatupang & Sridharan, 2008)

	Collaborative Communication		(Cao et al., 2010)
	Goal Congruence / Decision synchronization		(Cao et al., 2010; Scholten & Schilder, 2015)
	Resource sharing		(Cao et al., 2010)
	Collaborative planning	For instance described by (Daugherty et al., 2006): Collaborative Planning, Forecasting and Replenishment (CPFR)	(Christopher & Peck, 2004; Daugherty et al., 2006)
	Early design collaboration		(Lee, 2002)
Agility	Business continuity planning		(Norrman & Jansson, 2004)
	Internal integration	Better coordination and connection in the response on disruptions	(Braunscheidel & Suresh, 2009)
	External integration with key suppliers	Better coordination and connection in the response on disruptions	(Braunscheidel & Suresh, 2009)
	External flexibility		(Braunscheidel & Suresh, 2009)
Contingency Planning	Resource reconfiguration	Reconfigure, realign, and reorganize resources	(Ambulkar et al., 2015)
	Supply chain reconfiguration	Reconfigure supply chain by avoiding non-usable segments	(Blackhurst* et al., 2005)
Market Position	Increase market share		(Pettit et al., 2010)
	Increase financial strength		(Fiksel et al., 2014)
Knowledge management (post-disruption)	Learn from disruptions	Find better solution/reaction for future	(Ponomarov & Holcomb, 2009)
Building social capital	Invest in trust		(Seville et al., 2015)
	Leverage co-creations processes		(Seville et al., 2015)

Table 2: Overview of different managerial practices per element of supply chain resilience.

Situation Awareness is the first element that will be discussed in this part. The practices within this element are focusing on mapping supply chain vulnerabilities (Melnyk et al., 2010, p. 37), looking for and detecting risk (Priya Datta et al., 2007, p. 188) and avoiding them. Certain specific practices found in literature are risk analysis/assessment, for instance brainstorm sessions (Raj Sinha et al., 2004, p. 158), and identifying specific risks (DuHadway et al., 2019, p. 191). DuHadway et al. (2019, p. 191), describe for instance that identifying specific risks can help design appropriate safeguards for these risks. Brainstorm sessions are described by Raj Sinha et al. (2004) to be sessions with persons of different backgrounds to come up with all different kinds of risks. This can be a usable element, as it may create an understanding of when the risk of a volatile energy

price is higher and therefore when to act on this risk. Mapping supply chain vulnerabilities (Melnyk et al., 2010) will for instance help in getting to know which parts of the supply chain are most dependent on energy and help in getting to know how to participate on this.

Robustness is the next element of SCRES. The managerial practices of robustness are focused on designing the supply chain and a firms products to enhance SCRES (Craighead et al., 2007, pp. 134-135; Khan et al., 2012, p. 325). Tang (2006, p. 39) describes nine different robustness strategies to manage supply and demand better in normal circumstances and to be able to keep doing business in disruptions. Only the ones described for supply are interesting in this research, of which examples are postponement and make-and-buy. Postponement increases product flexibility, due to the ability to quickly change configurations, where make-and-buy enables the firm to shift between in-house and outsourced production (Tang, 2006, p. 39). This element and its practices also might be useful to decrease the risk of a higher product price and non- availability of products due to a more volatile energy price. Focusing on products of which you can change the configuration can for instance result in being able to change the product to decrease its dependency on energy for production and therefore decreasing the described risks of this research.

Knowledge Management (pre-disruption) is the next element of SCRES that is described by Ali et al. (2017, p. 25). Some examples of explicit managerial practices are supply-chain drills, simulations and exercises, in which disruptions are simulated, and education and training (Jüttner & Maklan, 2011, p. 254), so that employees know what to do when disruptions occur (Rice & Caniato, 2003, p. 27). This is also a valuable way to test the business continuity plans of your company. Implementing this could mean that disruptions are acted towards faster, which makes the impact of them lower. Looking at the literature it can be an element that is working for almost every kind of risk/disruption, as you create a situation in which your employees know what to do when a certain disruption happens. For instance, when you train them to react to price increases or non-availability, they know better how to react than when they are not trained.

Security is another post-disruption element of SCRES (Ali et al., 2017, p. 25). It is focused on increasing the defense against deliberate attacks by certain entities, to increase cyber- and freight-security by identifying suspicious elements (Manuj & Mentzer, 2008, p. 210). In some cases is it also to be said to decrease SCRES, as more security and customs regulations increase the time for product to flow through a supply chain, which makes them more vulnerable for disruptions (Blackhurst et al., 2011, p. 383). An example of a best practice is having a clear and formal security

strategy in place, in which all initiatives to increase security are documented (Rice & Caniato, 2003, p. 27). In literature not much is said about this element, probably because energy does not really relate to cyber or freight security, and therefore it is not expected to influence these risks.

Visibility is the last pre-disruption SCRES element described by Ali et al. (2017, p. 25). It can help warn companies of disruptions, which gives them the opportunity to align their capabilities to the risks and decrease the impact of a disruption (Stecke & Kumar, 2009, p. 214). It can also help in getting to know transportation cost due to charging prices, due to better information sharing between the buyer and supplier (Ali et al., 2017, p. 27). Certain managerial practices are described, such as inventory management, which gives higher visibility in supplier operations and transportation and reduces supply uncertainty (Stecke & Kumar, 2009, p. 212). Another practice is to use key performance indicators, to monitor supply chain disruptions and in that way increase its visibility (Ambulkar et al., 2015, p. 113). With taking the underlying literature into consideration, this can be an important element in the case of this research. As higher visibility might take away the described low visibility on energy prices in supply chains (Mulhall & Bryson, 2014, p. 332) as members of supply chains share more information. And joined inventory management/inventory flow monitoring can reduce the risk of non-availability as the companies know the situation the other is in, as they really need the product, or can lower the need, because they know it will not be available.

Flexibility is the first during-disruption element of SCRES that is described by Ali et al. (2017, p. 25). Tang and Tomlin (2008, pp. 15-16) describe two different practices to create a more flexible supply, 1) having multiple suppliers and 2) having flexible supply contracts. With the first one, supply cost risk will decrease, as the buyer can just choose the supplier with the lowest cost (Tang & Tomlin, 2008). Supplier flexibility can also decrease the risk of not getting the goods you need as a buyer (Lee, 2002, pp. 110-111), as there are more suppliers to buy from, which decreases the dependency on these suppliers (Hosseini et al., 2019, p. 295). When having a flexible supply contract, supply quantities can be changed through the duration of the contract (Tang & Tomlin, 2008, p. 16), and delivery and logistic risks can be reduced (Kesen et al., 2010, pp. 183-186). Sreedevi and Saranga (2017) make the distinction between supply, manufacturing, and distribution/logistics flexibility, where for this research, supply and distribution/logistics flexibility are the ones to focus on. They refer to the finding of Swafford et al. (2006), in which they say that effective supplier relationship management also is a strategy that increases flexibility, through

practices like joint decision making with key suppliers. As a result of the things described above, Flexibility is expected to be one of the most important elements for the specific risks of this research.

Redundancy is another element of SCRES that can reduce risks/increase competitive advantage in supply chains (Ali et al., 2017, p. 26). Investment in capital and capacity prior to the need for it and committing to supply contracts before needed are examples of practices. It is different from flexibility, as it is focused on maintaining capacity instead of redeploying capacity (Rice & Caniato, 2003, p. 26). Another well-known and widely used practice is maintaining safety stock (Sheffi & Rice Jr, 2005, p. 44). Even though redundancy can decrease the impact of disruptions, it also brings a significant cost to the company, of which you never know if it will pay itself back (Sheffi & Rice Jr, 2005, p. 48). This results in companies only implementing it up to a certain level. As the risks described in this research are influencing a buying companies business continuity, for instance when products needed for production are not delivered, a more redundant capacity, will reduce the outcomes of this risk. Therefore, it is expected that this element might also prove useful for the risks described in this research.

Collaboration is the next element of SCRES described by Ali et al. (2017, p. 27). A lot of different practices are described in literature, for instance Cao et al. (2010, p. 6617), describe seven different managerial practices to increase collaboration and SCRES. 1) Information sharing, 2) Goal congruence, 3) Decision synchronization, 4) Incentive alignment, 5) Resource sharing, 6) Collaborative communication, and 7) Joint knowledge creation. Scholten and Schilder (2015, p. 480) also describe that information sharing, collaborative communication and joint relationship efforts increase resilience within a supply chain and between firms. Jain et al. (2017, p. 6781) say that incentive alignment can be used as a practice to increase collaboration. This could be done by sharing the cost of production, so that the supplier can keep producing and earn money and the buyer gets what he needs (Jüttner & Maklan, 2011, p. 254; Mentzer et al., 2001, p. 8). By looking at it like this, the buyer and supplier also share the risk of production cost getting higher, which makes them both more able to respond to the risk and willing to help each other (Kache & Seuring, 2014, p. 670; Pettit & Beresford, 2009, pp. 461-462). Collaboration can for instance also result in planning the most cost-efficient delivery moments to be able to charge the vehicles at the lowest price possible to decrease delivery and logistics risk, with collaborative planning also increasing visibility (Christopher & Peck, 2004, p. 10). Collaboration is also described in a lot of literature to

be influencing other elements of resilience, such as visibility, agility, and flexibility (Faisal et al., 2006, p. 545; Scholten & Schilder, 2015, p. 480). Looking at the things from literature described above, collaboration is probably going to turn out to be a very important way of reducing the specific risks described. For instance, decreasing non-availability by incentive alignment or cost sharing, or decreasing the risk of price increases by joint relationship efforts.

Agility is the last during-disruption element of SCRES (Ali et al., 2017, p. 27). An example of a practice is business continuity planning (Norrman & Jansson, 2004, p. 438). Braunscheidel and Suresh (2009, p. 121) describe three different practices, 1) internal integration, 2) external integration with key suppliers and key customers, and 3) external flexibility. Internal and external integration is focused on creating better coordination and connection in the response on disruptions by a firm and its supply chain (Braunscheidel & Suresh, 2009, p. 123). This can contribute to reduce the specific risks described, by creating a plan to reduce the impact of a higher/more volatile energy price jointly with important suppliers. As said before, business continuity planning might also prove important.

Contingency Planning is the first element described by Ali et al. (2017, p. 27) for post-disruption practices. Some practices described are resource reconfiguration and supply chain reconfiguration. Resource reconfiguration is described by Ambulkar et al. (2015, p. 112), as: "the ability of a firm to reconfigure, realign and reorganize their resources in response to changes in the firm's external environment". Supply-chain reconfiguration can be described as the ability to reconfigure the supply chain by finding another way through the supply chain, by avoiding particular non-usable segments of the supply chain (Blackhurst* et al., 2005, p. 4076). Looking at literature this can be helpful in reducing the specific risks described in this research. As a buying company can look back at the high/volatile energy prices in 2022, look at which nodes in the supply chain or with what products they had problems and therefore reconfigure them accordingly.

Knowledge management (post-disruption) is another post-disruption SCRES elements described by Ali et al. (2017, p. 27). It focusses on enabling a firm and its supply chain to learn from disruptions and the events that occurred in its aftermath. This can be linked to the contingency planning in a way that it can be used to look back and see where the problems occurred and use that to act in the future. Looking back at what occurred at their company in the period of a high energy price, can help companies to improve their response when it happens again in the future, but it is not expected to be very important now.

We here described the 11 elements of SCRES that are expected to directly influence the risks of higher prices or material availability. Of these 11, Collaboration, Flexibility, Visibility and (Pre-disruption) Knowledge Management are expected to be very useful, where the others are expected to be less influential. Next to that, are 2 elements that are expected to have an indirect influence, which will be described in the next part.

Supply chain position in relation to managerial practices

Market position is the next element described by Ali et al. (2017, p. 27), which is a pretty straightforward element. This element focuses on the ability of a supply chain to recover from disruption, because they are financially strong (Fiksel et al., 2014, p. 81) or have an increased market share (Pettit et al., 2010, p. 12). When a buying company has a good market share, they can just increase their own prices when the prices of the products they buy increase. Therefore, it is to be expected that this might not be useful as an element to influence the risks, but it is one, that influences the outcomes and impacts of the risks. It is also expected to be a complementary element as having a higher market share makes you stronger and makes it easier to implement other elements as you have more power within the supply-chain.

Building social capital is the last element described in the paper and model of Ali et al. (2017, p. 27). It focuses on supply chain partnerships and how these can increase SCRES and all its elements. Building this social capital can be enhanced by deploying certain managerial practices, such as investing in trust within the supply chain and leveraging co-creation processes (Seville et al., 2015, pp. 10, 16). In literature is shown that it might not really be a direct element of SCRES, but that it influences a lot of other elements of SCRES, such as flexibility, visibility and collaboration (Johnson et al., 2013, p. 330). Therefore, the expectation is that it in general can be an important element to take into consideration, when trying to implement other elements.

By looking at the things described before, the research model showed below was created. Building Social Capital and Market Position are showed to influence other SCRES elements. In the next chapter will be described how we will research if our expectations and findings in literature will come out and show to be true in practice.

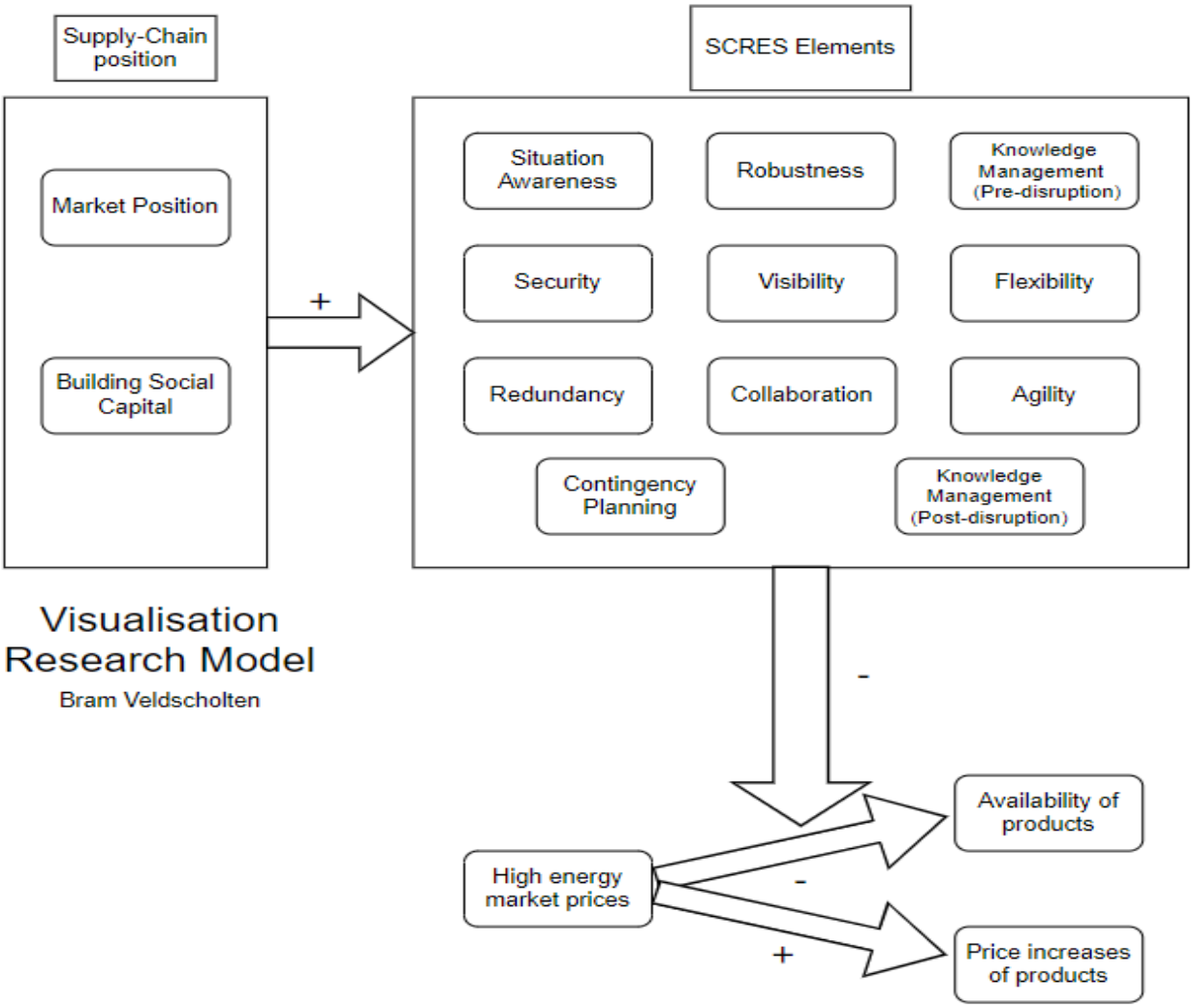

Figure 3: Visualization Research Model

3. METHODOLOGY: QUALITATIVE CASE STUDY

3.1 Research Design: a literature review in combination with a qualitative case study including interviews.

In this research a literature review is empowered with a case study to get a clear view on what SCRES elements are most useful to decrease the risks described in this research. The literature review focused on the topics described in chapter 2. For this was searched for articles with the origin between 2017 and 2023 and from the subject areas of Business, Management and Accounting and, Economic, Econometrics and Finance, of which the results can be seen in Appendix III. After this, snowballing was used, to find a network of relevant articles (Lecy & Beatty, 2012, p. 5).

To investigate whether the SCRES elements are indeed helpful in reducing the risks described, a qualitative case study with interviews was included. This was done to get to know if the high energy price really causes the risks described in the model and how the SCRES elements can influence these risks. Interviews with both buyers and suppliers of the case company were conducted.

To get a clear vision of the relationship between energy price volatility and supply chain disruption risk, the knowledge and experience of the buyers and suppliers is an important source of information. By analysing this, a clear understanding of the phenomenon mentioned before was gained, for which interviews are very useful (Gill et al., 2008, p. 292). And as interviews help with analysing underlying beliefs and experiences, they are fitting for phenomenon of which little is known (Gill et al., 2008, p. 292).

3.2 Sampling: 3 strategic buyers and 15 of the biggest suppliers.

Interviewee	Company / Function	Duration of interview
Buyer 1	Manager Purchasing Adhesives / Plastics	49:12 minutes
Buyer 2	Manger Purchasing Projects	30:50 minutes
Buyer 3	Sourcing Leader	42:32 minutes
Supplier 1	Managing Director	27:49 minutes
Supplier 2	Key Account Manager	47:43 minutes
Supplier 3	Market Segment Manager	34:36 minutes
Supplier 4	Senior Sales Executive	33:12 minutes
Supplier 5	Area Sales Manager	27:44 minutes
Supplier 6	Marketing Director	52:38 minutes
Supplier 7	Head of Market Segment Europe	48:24 minutes
Supplier 8	Sales Manager Key Accounts	36:43 minutes

Supplier 9	Key Account Manager	51:16 minutes
Supplier 10	Business Unit Manager	31:47 minutes
Supplier 11	Account Manager	43:15 minutes
Supplier 12	Area Sales Manager	50:34 minutes
Supplier 13	Account Manager	25:12 minutes
Supplier 14	Owner	28:11 minutes
Supplier 15	Managing Director	48:08 minutes

Table 3: Interviewees, their functions, and the duration of the interviews.

As this research is focused on strategic procurement, the purchasing managers and the sourcing leader that focus on that, were interviewed. This was done to get a clear understanding of how they manage disruption risks currently and what they think of the managerial practices spoken about in this research.

The selection of suppliers was spend based on data from the ERP system of the case company. The top 15 suppliers at which the case company has the highest spent, were selected for interviews. These are suppliers in all kinds of commodities, such as PVC pipes, electronical equipment, steel, adhesives, resins, and chemicals, to get a clear overview of the whole supply chain. It is the most interesting, as the suppliers at which the case company spends the most money, are the ones that therefore can generate the most risks in our case, because a higher product price has a bigger impact and they deliver more material, so no material availability creates a higher risk.

3.3 Interview protocol: questions to touch the different aspects of the research model.

For this research two different questionnaires were developed, one for the purchaser's perspective (see Appendix I) and one for the supplier's perspective (see Appendix II). Table 4 shows examples of how the different concepts are asked about with supplier and buyers.

Concept from Research Model:	**Question:**	**Interview:**
Market Situation during time of high energy prices	"Are there some specific buyer-supplier relationships that came up during the time of high energy prices?"	Supplier
	"Can you describe what your company experienced when the energy prices started to rise?"	Supplier
	"Are there some specific situations that came up during the time of high energy prices (in the last months of 2022,) and could you describe them thoroughly?"	Buyer
	"Where these situations really due to high energy prices and was this communicated to you by the supplier, or do you expect it to be due to high energy prices?"	Buyer
SCRES Elements in times of high energy price	"How did the behavior of buyers towards you change?"	Supplier

	"Were there situations in which the change in behavior of a buyer lead to problematic outcomes?"	Supplier
	"Were there situation in which the change of behavior of a buyer lead to success or a good outcome?"	Supplier
	"Imagine if a buyer suddenly started to focus very much on... (Element)…., how would you have reacted to this?"	Supplier
	"In my research I also describe …. as a possible strategy, why did you not implement this? Do you think it would have worked?"	Buyer
	Imagine if a buyer suddenly started to focus very much on … (SCRES element) …, how would you have reacted to this? And what would this have led to?	
SCRES Elements and its influence on product price	"Did you make a difference between prices per buyer/customer? What were the reasons for this?"	Supplier
	"How were the problems caused by the higher product price solved or how where they not solved?	Supplier
	"What strategies did you implement as a buying company to act on the problems that occurred, to decrease the possibility of increasing prices or non-availability of products?"	Buyer
SCRES Elements and its influence on material availability	"Did you differentiate between which suppliers you still delivered to and which not?"	Supplier
	"How were the problems caused by the higher product price solved or how where they not solved?"	Supplier
	"What strategies did you implement as a buying company to act on the problems that occurred, to decrease the possibility of increasing prices or non-availability of products?"	Buyer
Energy Price and its influence on product price	"Did the high energy prices lead to your company needing to change the prices for your customers?"	Supplier
	"If yes. Why exactly did you change your prices, and did you communicate this to your customers? "	Supplier
Energy Price and its influence on material availability	"Were there situations in which your company was not able to deliver your products to your customers anymore?"	Supplier
Market Position and its interrelationship with other SCRES Elements	In interviews with supplier often asked in follow-up questions when they talked about purchasing volume or a big customer, if this also influenced the implementation of other strategies.	Supplier
	"Do you also think that it might influence the outcomes of implementation of the other SCRES elements?"	Buyer
Social Capital and its interrelationship with other SCRES Elements	In interviews with supplier often asked in follow-up questions when they talked about a good relationship with a customer or trust in each other, if this also influenced the implementation of other strategies.	Supplier
	"Do you also think that it might influence the outcomes of implementation of the other SCRES elements?"	Buyer
Market Position and its influence on the risks caused by a high energy price	"Do you think that the strong market position/financial strength of [company name] influences the risks of price increases or non-delivery of suppliers products?"	Buyer
Social Capital and its influence on the risks caused by a high energy price	"Do you think that partnerships within the supply chain influences the risks of price increases or non-delivery of supplier's products?"	Buyer

Table 4: Concepts from research model and the linked questions in the interviews.

The questionnaire for the purchasers focused on getting to know what they are currently doing and what they think about the managerial practices I described and if they could work in practice to decrease energy risk. The questionnaire consists of 4 parts. The first part is focused on introducing the situation, the second on getting to know what strategies the case company implemented when the energy prices spiked, and the last two on Market position and social capital and their influence on other SCRES elements. Next to that I came back on elements of SCRES not mentioned.
The questionnaire for the suppliers also consists of 4 parts. Part 1 is an introduction, where the second part focusses on getting to know what they experienced when the energy prices were high, how buyers changed their behavior and what the outcomes were from these situations. In part 3 was asked whether the supplier changed their prices, how buyers reacted when they did and if certain elements had an influence on this, where the last part does this for delivery problems. Also, will in all interviews be asked back to certain SCRES elements, to ensure that all SCRES element are discussed.

3.4 Data analysis approach: coding scheme to create an overview of the interview results to compare with literature review.

All the interviews conducted were transcribed. This was done by putting the recordings in Amberscript, which automatically transcribed the interviews and afterwards the results were coded with Atlast.Ti.
After checking the transcriptions, the transcripts were coded. This coding was done by combining deductive and inductive coding. To test the data retrieved from the literature review, deductive coding was used (Elo & Kyngäs, 2008, p. 111). This research also needs to stay open for the input of the interviewees and therefore no purely deductive coding was used. The inductive coding was used to point out the underlying experiences and beliefs around the different managerial practices that can be implemented, as this is linked to a framework deducted from literature (Burnard et al., 2008, p. 429).
All answers that were perceived to be useful for this research were given an individual code, and subsequently were grouped based on the different themes and aspects talked about in this research, such as the different SCRES elements. Codes that are about things having the same effect, were merged into one code. The coding scheme that was used can be seen in table 5. In the table, a systematical way of coding is showed, in which first the SCRES element is mentioned, then the

specific practice, then whether it has a positive (P) or negative/no influence (N) and then if it influences material availability (M) or product price (P).

Research Model Concept	Relationship	Coding Scheme
SCRES Elements and its influence on product price	Positive	SCRES Element – Practice – P - P
	Negative/No	SCRES Element – Practice – N - P
SCRES Elements and its influence on material availability	Positive	SCRES Element – Practice – P – M
	Negative/No	SCRES Element – Practice- N – M
SCRES Elements and its general influence	Positive	SCRES Element – Practice – P -
	Negative/No	SCRES Element – Practice – N -
SCRES Elements Interrelationships	Positive	SCRES Element ++ SCRES Element
	No	SCRES Element +- SCRES Element
	Negative	SCRES Element - - SCRES Element
Energy price influence on product price		Energy price increase, caused product price increase
		Energy > Raw material > Product Price
Energy price influence on material availability		Energy price increase, caused low material availability
		Production stops due to high energy cost
Additional Codes outside of the concepts		Availability more important than price
		Product price increase accepted easily
		Product price increase caused unhappiness

Table 5: Coding Scheme used for Analysis interviews.

On the answers given in the different group codes, a clear analysis of the influence of different SCRES elements is built in the next chapter.

3.5 Data Quality and Reliability: Increase generalizability, accuracy, and comparability, decrease skewedness.

In this research certain steps have been taken, to ensure the quality and reliability of the data, which will be summed up here.

Purchasers that focus on strategic procurement were interviewed, as this is what we focus on in this research. Also, direct accounts at suppliers of these purchasers were interviewed, to make the results comparable and be sure that they understand the situation of the specific company and supply-chain. To make the findings of this research more generalizable, also newer supplier were interviewed, and not only suppliers with which a good relationship is established. Therefore, the sampling is spend based and the suppliers were not selected by the purchasers of the case company. Interviews with both suppliers and buyers were done, to not get a one-sided story and be able to

compare the different perspectives. In the interviews was asked back to SCRES elements not yet discussed, to make the data as inclusive as possible.

To ensure unified results, different technical solutions were used, such as the Voice Memos App on iPhone, Amberscript and Atlast.Ti. Some interviews were conducted in Dutch, these interviews were all translated back to English. All the interviewees were asked to voluntarily sign an interview agreement in accordance with the UT ethical approval, in which they also approved for a recording. Atlast.Ti enabled me to transcribe and code the interviews. The transcription was manually checked for accuracy and adjusted where needed. The coding of the transcriptions was done in a systematical way, to be sure that every answer and interview was treated in the same way.

Before the interviews was said that the results would not be shared with the case company, and they were used for this research. This was done to increase the honesty and possibly let them feel free to be less positive about certain situations discussed.

This research also has five specific limitations. The sample size is one of them, but as this research needs to be done in a restricted amount of time, it is seen as sufficient for this research. The role that the interviewees have in relation to the case company, was before described to be chosen like this, as it empowers the research, but it can also create a positive bias, because the case company may be an important buyer for the suppliers. In this research is only focused on one supply-chain, which means that the results found may be different when considering other supply chains. Next to that the focus of this research might create a bias when regarding other kinds of disruptions. As there is only focused on the disruption of the energy price and the risks linked to it and a lot of questions have been devoted to the influence of Social Capital and Market Position. The last limitation is the exclusion of diminishing energy consumption, as this might be a successful way of decreasing the risks of an energy price spike disruption. How these limitations can be reduced and how future research should do this, is described in chapter 6.3.

4. ANALYSIS AND RESULTS

The description and explanation of the interviews will be divided into distinct parts: Impact of the energy price, SCRES elements influencing product price, SCRES elements influencing material availability and interrelationships between SCRES elements. This will come together in the next chapter by concluding which SCRES Elements are most important when regarding the energy price, and whether this is different than expected. Key quotes regarding certain topics, can be found in Appendix IV.

4.1 Impact of the energy price on the market.

Seen from the results can be said that on the one hand, the Energy price has an impact on the product price, both indirect (through the raw material price) and direct. On the other hand, the energy price has a direct impact on the material availability. Another interesting finding is that in the end there was an acceptance by the whole market on the energy price, which was caused by the overall focus on material availability and being able to keep producing was priority one.

4.1.1 The Energy price and its influence on both product price and material availability

The energy price is said to have both an influence on the product price and the material availability. Next to both a direct and an indirect influence on product price, the interviewees stated that the energy price also influenced material availability, because a lot of production was stopped or decreased.

3 codes about the energy price and its influence on product price and material availability were found. The first one is “Energy > Raw material > Product price”, where the higher energy price is described to really cause raw material prices to increase, what again influenced the product price to increase. As one interviewee stated: “But energy price has the biggest impact on raw material price. So, in fact, it is not directly related things, but yeah, we just simply felt energy prices on our raw material.”.

The second code is “Energy price increase, caused product price increase”, in which interviewees directly linked the product price to the energy price. Prices of products were increased because the production process just became a lot more expensive. A supplier described: “[name company] also has a certain position to stand firmly and say: no, energy prices we also have to pay much more. It also ends up costing us a lot more to produce something”.

“Energy price increase caused low material availability” is the last code. This code describes that the energy price influences the production of goods and therefore creates a lower availability of materials. Also force majeures were mentioned as result of the high energy prices. That the energy price indeed influences the availability of materials is empowered by the fact that the code “production stops due to higher energy costs” was found 9 times.

Looking at what is described in this subchapter, it can be stated that the energy price has an influence on both product price and material availability. On the one hand because it influences the production price of both raw materials as products later in the supply-chain and on the other hand, because it makes the production process so expensive that production is decreased or stopped.

4.1.2 Habituation and acceptance of product price increases, as result of hyperfocus on material availability.

Two highly mentioned circumstances in the market are the facts that material availability was more important than the price that companies had to pay for their products and therefore the higher prices of products were accepted quite easily. Also, the influence of macroeconomics on and the extremity and global influence of the energy price was pointed out by interviewees.

One thing to note is that both suppliers and buyers stated that being sure that you have your material to produce, was more important than the price that had to be paid for it. One of the main reasons for this is because most of the interviewees also mentioned that they could charge a higher price. Certain quotations that enhance this are: “at the end it was just about getting the product delivered for the continuation of our business” and “There was only the question: can you deliver it? And not anymore what is costed”.

Maintaining delivery and getting the materials was therefore one reason why the market accepted price increases easily, where habituation and understanding are the other reasons. With the habituation, the fact that the energy price increase came after some other macroeconomic situations, like Covid-19 is meant. After a certain period, everyone also knew why the price increases were implemented, and they also needed to do it themselves, so a certain understanding was created in the market. It also needs to be addressed that suppliers pointed out that they have never seen a market sentiment like this before and with these kind of price increases. Also was said that it was a global problem, and you could not really try to get it somewhere cheaper or faster, like an interviewee stated: “because it was, like I just said, wasn't a Dutch thing, it was a global thing. Everyone was affected by it “.

This subchapter shows that a sentiment in the market had been created, where everyone put priority on getting the material they need and thereby not really caring about what the price was for that. The results of a disruption due to the higher energy price was by suppliers pointed out to be the most extreme and globally disrupting they have ever seen before, maybe this also was the result of certain macroeconomic situations coming after each other.

4.2 SCRES elements influencing product price: Market position and social capital as most influencing.

From the interviews can be seen that both Market Position as Social Capital have a direct influence on product price, which was from the model expected to be an indirect influence. A good Market Position shows to have a positive influence on the product price, where the interviewees are not aligned on the influence of Social Capital. The opinions on Flexibility were also divided and, Visibility is described to have a positive influence on the product price.

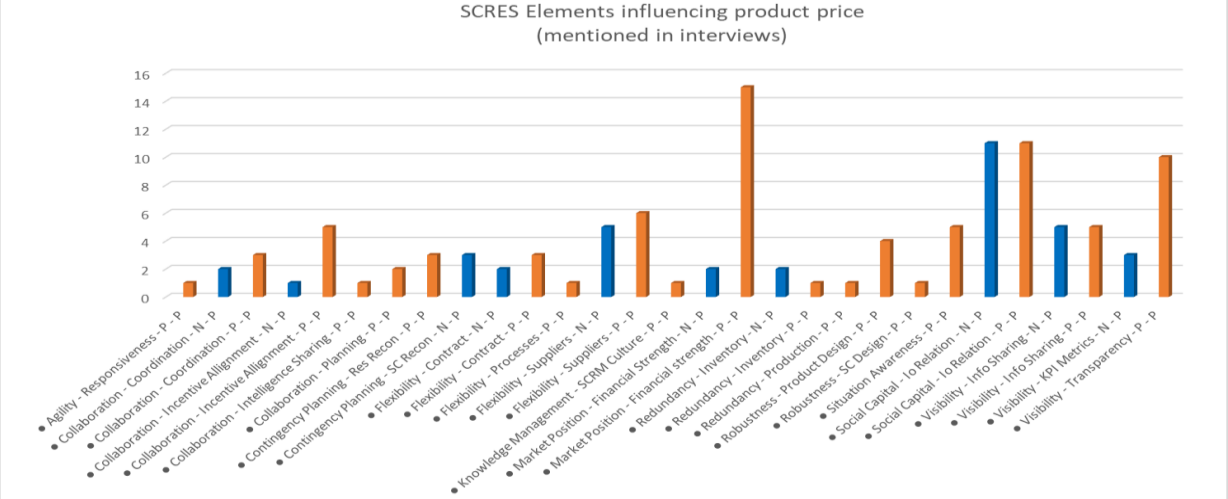

Figure 4: SCRES Elements influencing product price (blue=N-P, orange=P-P).

In the chart showed above (See figure 4), the answers given by both purchasers and suppliers about what influences product price increases can be seen. Market Position was shown to have a positive influence on the product price. Here it often

was about that when you buy in higher volumes, you get a discount on price. As stated by one interviewee: “Volume is key, so when a customer buys more, he gets a better price, but this is a normal sales rule”. The suppliers were mainly talking about discounts, where purchasers were mainly talking about being able to influence the price, because of the good market position of their company.

One other result that stands out is that Social Capital is mentioned as having a positive influence on the product price of customers, but also as a negative/no influence on the product price. Some suppliers explain the positive influence by that they gave discounts or price deferrals during the price increase, because they have a good and long-lasting relationship with their customers. Suppliers said things like this: “Yes 100 percent. In the case of [company name] for example, we really looked at the relationship. You may know that we have also made less turnover or profit, than we need as a company on the deliveries for [company name]”. General behavior and keeping prices low in a good relationship also were mentioned.

For the high score regarding the negative/no influence of Social Capital on product prices, some different things were pointed out. 1) a good relationship, also comes with good services and quality, which just means that price also is higher, 2) when in a good relationship, price increases are just accepted earlier and 3) that relationship should not have any influence on prices. Out of the 22 quotations on Social Capital, only 2 came from purchasers, which shows that they do not really think it has an influence on their purchasing price.

Also interesting is that Flexibility in Suppliers scored moderately high on both negative/no and positive influence. The negative influence seems to be because it was implemented to get supply and that price did not really matter. The high score in positive influence looks to be because of the main image it has, to be a good strategy to reduce price in normal circumstances, but as can be seen by the answers linked to negative influence it seemed to not be a good strategy in our case, as one of the real problems here was material unavailability.

Looking at the high score of Transparency, there was mainly talked about when a lot of transparency in costs was given during the high energy prices, it resulted in customers coming back for price decreases. It was also mentioned by purchasers that the problem was not in the transparency of energy market price and costs, as there were indexes about that, but the different ways of calculating product price was the main difference between suppliers. When a cost-breakdown was given, customers afterwards had more power in negotiating a lower price.

From the results described in this subchapter there are some main takeaways. Market Position is described to have a positive influence on product price, where on Social Capital the interviewees do not agree. Supplier Flexibility was described to not be a good SCRES element to influence price in the described situation, but Transparency is, as it enables purchasers to negotiate for a better price.

4.3 SCRES elements influencing material availability: Collaborative Planning and Inter-Organisational Relation as most positive SCRES elements.

In this subchapter some interesting findings are described on material availability, for instance that Social Capital and Collaborative Planning are the most influencing SCRES elements regarding material availability. Redundancy and Supplier Flexibility are both described to be helpful in normal situations, but not in the situation of a disruption due to a high energy price, which shows those elements should be approached differently when regarding energy price as a disruption.

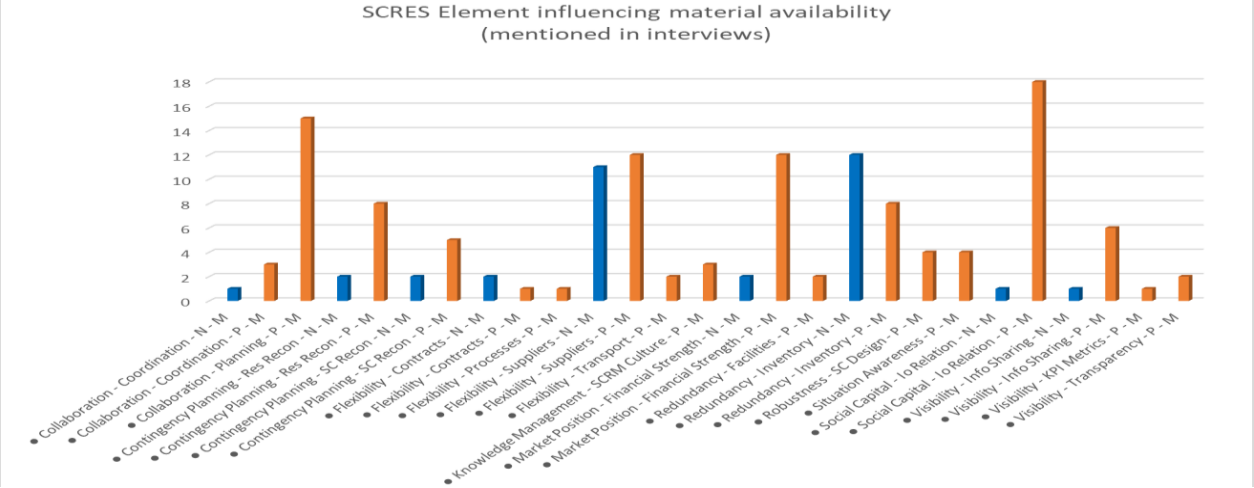

Figure 5: SCRES Elements influencing material availability (blue=N-M, orange=P-M).

There are 4 strategies that show to be mentioned positively often and almost never negatively (see figure 5). Social Capital is the SCRES element that was mentioned positively by interviewees. It has been showed to positively influence the delivery of materials in the time of the high energy prices. As one of the interviewees stated: “then you start looking together that you also let the most loyal customer suffer as little as possible to still deliver the stuff”. Suppliers also said that their general philosophy is to always deliver to regular/loyal customers first.

About Collaborative planning is said that planning together increases the likelihood of being able to get your products delivered, as supplier know when you need what and maybe can influence that planning a bit. It seems to be important also in normal market conditions, but when such a disruption occurs as the energy price, the importance of it is really outlined.

The two other strategies mentioned positively as an influence on material availability are Contingency Planning - Resource Reconfiguration and Market Position. Resource Reconfiguration is focused on finding alternative resources to use for your own production, that have less risks

attached. Validating alternatives together could result in higher material availability, also because suppliers have better insight in that side of the market. Market Position again scored high, as was described that when suppliers must make a choice between which customer they will deliver too in times of scarcity, their most valuable and biggest customers will be the first ones to receive their delivery.

There were also 2 elements, on which the interviewees did not agree. Inventory Redundancy and Supplier Flexibility were those. The times Supplier Flexibility was positively mentioned, if often was about just using it as a way of getting your materials from more than one supplier, to ensure delivery and quantity. The times it was put under the negative/no influence code, it was often about that it just has no influence on the outcomes of deliveries in the specific situation of this research. Because in times of scarcity, suppliers wanted to sell first to their regular customer. In some supply-chains, they do not even have the option to go to another supplier, as there are only a few. This shows that it is not a good strategy to implement for increasing Material Availability in the situation that occurs when energy prices are becoming very high.

The other SCRES element on which the interviewees did not align is Inventory Redundancy. It was mentioned to have both a positive as a negative/no influence. The times Inventory Redundancy was positively mentioned, half of the time it was mentioned by purchasers that they implemented this to reduce the risk of material unavailability. When mentioned negatively was said that during the time of scarcity, it was almost impossible for customers to buy more, as there were quotas and forecasts in place, based on what the customer bought in recent years. Customer that tried to buy a lot more to stock up, just would not get that quantity delivered. It seems that purchasers think it is a good strategy, where suppliers say it does not work.

In this subchapter we see that both Redundancy and Supplier Flexibility seem to have almost no influence when implemented in the specific situation of this research, even though they normally are described to be helpful. Social Capital, Collaborative Planning, Market Position and Contingency Planning (Resource Reconfiguration) all seem to be positively influencing the material availability.

4.4 Interrelationships between different SCRES Elements

As showed in the research model, Social Capital and Market Position are expected to have an influence on the effect and/or implementation of the other SCRES elements. Only some

relationships are mentioned as being influential, such as the relationship between Collaboration and Social Capital and Visibility and Social Capital. Visibility seems to be influencing quite some other SCRES elements, looking at the other interrelationships.

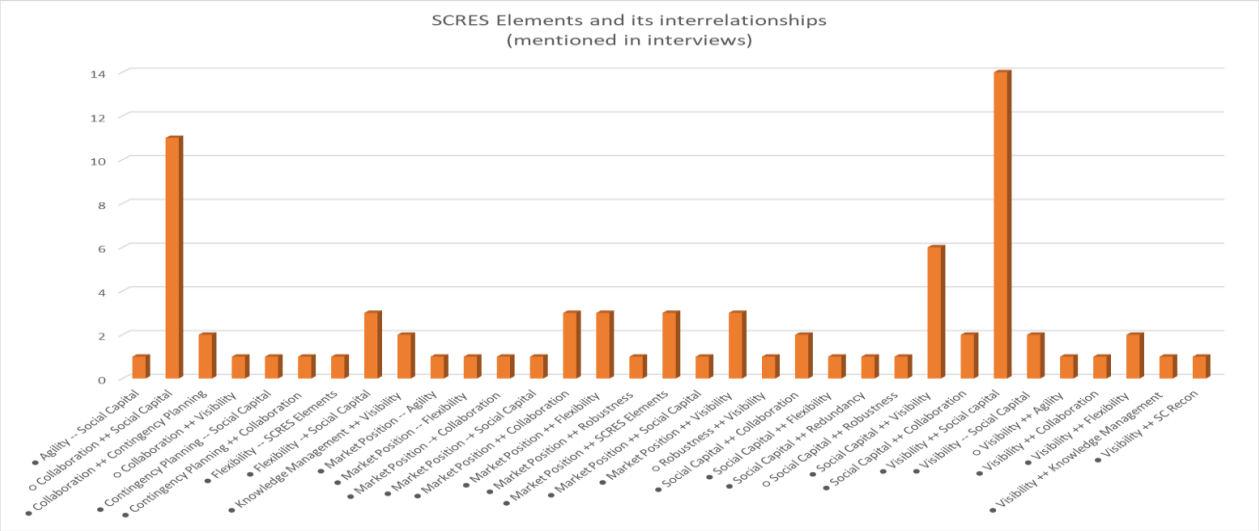

Figure 6: SCRES elements and its interrelationships.

The focus of this subchapter is on interrelationships revolving around Social Capital and Market Position, as these are mentioned the most and showed in the research model. The other elements are only discussed, when standing out.

4.4.1 Social Capital and its positive interrelationship with Collaboration and Visibility and its unexpected relationship with Flexibility

Interviewees mentioned Social Capital to have a positive interrelationship with Collaboration and Visibility, where both seem to be both ways. The interrelationship between Social Capital and Supplier Flexibility seems to be different than expected, as there almost seems to be no influence. Visibility is described to increase the relationship between a supplier and buyer. The most often mentioned was that sharing more information did positively influence the relationship. As one interviewee states: “Because you had so much more contact than usual, the relationship was getting stronger, and you get to know each other much better”.

Looking at the results Social Capital also seems to be positively influencing Visibility. It shows that information is easier shared with people that you know for a longer time, you have a relationship with and that you trust. As was described by a purchaser: “I can imagine, if you have a good relationship with a supplier, they are much more likely to go along with, let's say, delivering a cost-breakdown”.

Another relationship that was found is the positive influence of Collaboration on Social Capital. It shows that when a supplier works together with a buyer in making the best possible product with the right services and conditions, it will result in a better relationship. Incentive Alignment was also stated to be positively influencing a relationship, creating a win-win situation when it is good, but also sharing costs when something goes wrong.

There also are a lot more interrelationships between Social Capital and other SCRES elements found. One that directly stands out is Flexibility -+ Social Capital, which points to Flexibility not influencing Social Capital. This is different than you would expect, as Supplier Flexibility is expected to be negative for a buyer-supplier relationship, as it focuses on having a flexible supply strategy with multiple suppliers. A purchaser said that they would be honest about buying at another supplier, because that would not cause problems. Two suppliers even said that they understood dual sourcing to decrease the supply chain risk.

In this subchapter was described that Social Capital and Visibility are empowering each other, which seems to be a relationship that is happening in general. Social Capital is also showed to be positively influenced by Collaboration. The relationship between Supplier Flexibility and Social Capital is different than expected, as this seems not be influencing each other in this situation.

4.4.2 Market Position and its positive interrelationship with all SCRES Elements, especially Collaboration and Flexibility.

Market Position has been mentioned quite often in relation to other SCRES elements, nevertheless there are not really interrelationships on which statements stand out. There only are a lot that have been mentioned occasionally, such as that Market Position has a positive influence on all SCRES Elements, according to purchasers. Also does it have a positive influence on both Collaboration and Supplier Flexibility.

Market Position is showed to have a positive influence on all SCRES elements. This seems to suggest that with a good market position it is easier to implement other SCRES elements and that the outcome of these elements would be more beneficial. Looking at the quotations, most were from purchasers. They said that when having a good market position, you have “the power to get people in a certain direction”. Looking at the positive interrelationship between Market Position and Collaboration this also was mentioned, as this might suggest that suppliers would be more likely to go along with bigger customers in developments etc. than they would with smaller customers.

Also was the positive influence of Market Position on Supplier Flexibility pointed out. This shows that when customers with a bigger market position ask for an inquiry in times of scarcity, they would be more likely to be delivered to, as they have a high sales potential, and they can use their power to decrease the price, by threatening to go to another supplier. Things like this were said by interviewees.

Looking at this subchapter, there are some main takeaways. Market Position seems to have a positive influence on all SCRES elements, as supplier will be more likely to collaborate with all initiatives. It also gives buying firms more power to influence the supplier to do certain things as described before.

4.4.3 Visibility as an influencer for Flexibility, Agility and Collaboration

Some other SCRES Elements also seem to have an interrelationship with other elements. Some SCRES elements that seem to be mentioned quite often are Agility, Collaboration, Flexibility and Visibility.

The one that stands out is Visibility, as this seems to be in relation with the other Resilience elements. One that we already discussed is the interrelationship with Social Capital. Flexibility is also mentioned to be positively influenced by Visibility. This is because of the overall higher Visibility in the market that exists nowadays, as the internet is used more and more, and you can search for a supplier by only a click. This is something that is also like this in normal circumstances, but in such a disruption as the higher energy price you are more likely to switch.

Increased Visibility is also said to positively influence Agility. For instance, the transparency of suppliers in how big their stock is of a certain product, increases the responsiveness, as they see risks occurring earlier. Collaboration is another SCRES element that can be positively influenced by Visibility. Clear agreements based on showed costs of production can make it easier for both parties to collaborate in an honest way.

In this subchapter is showed, that Visibility also seems to influence quite some other SCRES elements. Flexibility, Agility and Collaboration seem to stand out. These relationships do not seem to be specifically applicable for this research, but more in common.

In this chapter, the findings on which SCRES elements seem to influence the risks or other SCRES elements in this research are described. In the next chapter, the model will be revised by using these findings. Also, will be concluded if the energy price really is different in being a disruption or not.

5. CONCLUSION

The goal of this research is to contribute to and examine the literature on SCRES elements (Ali et al., 2017; Christopher & Peck, 2004), energy price risk (Mulhall & Bryson, 2014) , supply chain disruptions (Althaf & Babbitt, 2021; Ambulkar et al., 2022; Blackhurst* et al., 2005) and how supply chain disruption risks can be reduced by implementing supply chain resilience (Ambulkar et al., 2015). This will be done to create an image on the disruption of a higher energy price and how/which SCRES elements can be implemented to decrease the risks of material unavailability and higher product prices resulting from this disruption. The revised model according to the results will be showed to give a concise summary that will be explained further in the chapter.

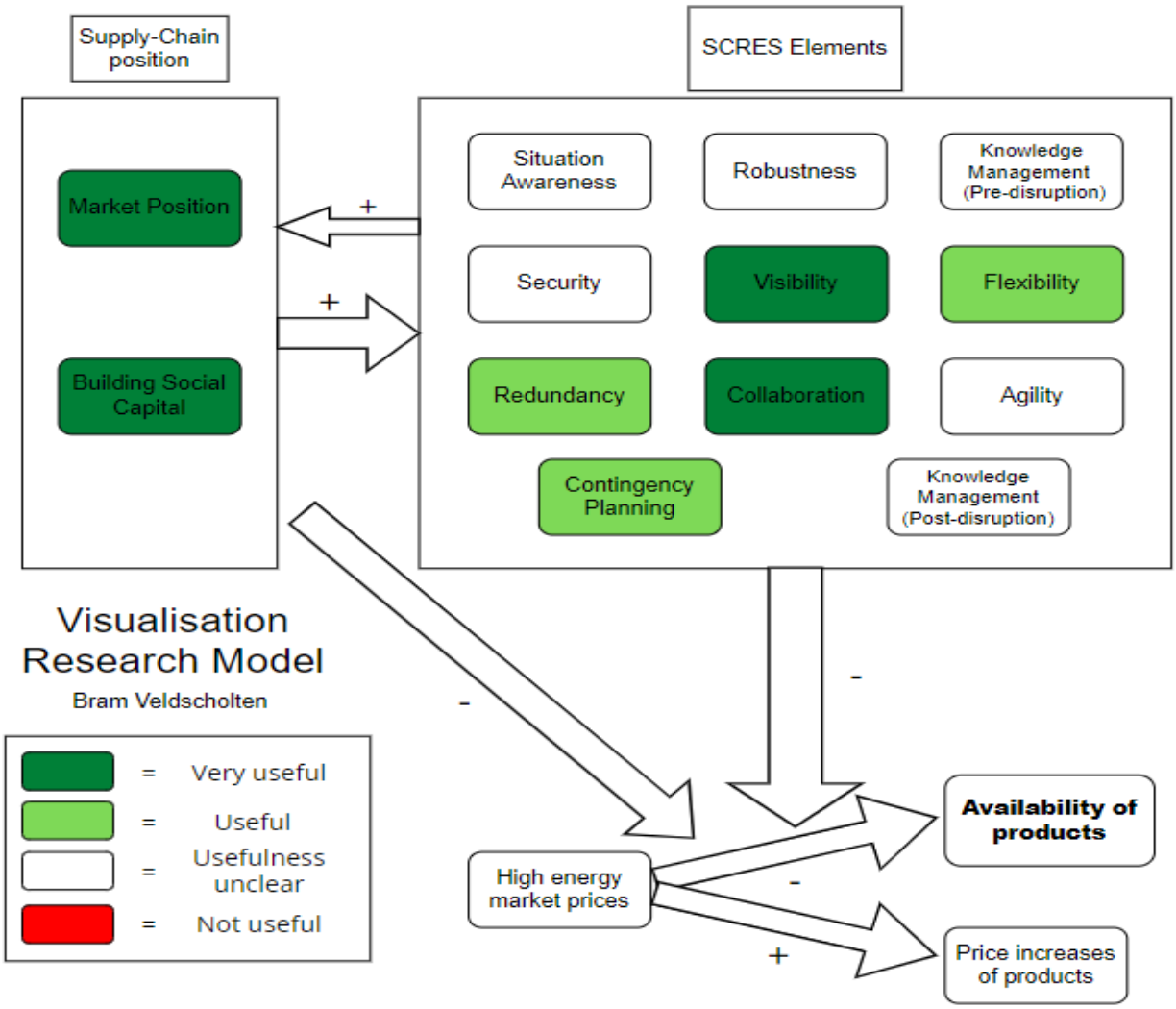

Figure 7: Revised Research Model

5.1 Energy price as a supply chain disruption

In this subchapter, a conclusion will be drawn on the situation created by the high energy price and how to deal with it.

5.1.1 Energy price as a direct influence on product price and availability.

The main takeaway from the findings of this research is that the increase in the energy price has next to a direct, also an indirect influence on the product price and the material availability. Next to that it also influences other triggers of supply chain disruptions such as force majeures and logistic problems. It means that the risks described in this research are indeed influenced by the energy price.

5.1.2 Macroeconomics influencing the energy price which at its turn influences triggers of disruptions globally.

From the results can be seen that there was an extreme sentiment in the market where everyone was prioritizing availability of supply over the product price, what resulted in the product price being accepted and not focused on that much. This was also because there was a high understanding and visibility on the fact that there is a risk created by the energy price, which is in contrast to the research of Christopher and Holweg (2017, p. 10). The acceptance of the price is also due to certain macroeconomic situations, such as the war in Ukraine and Covid-19, and the fact that energy has a global impact. In the end, we can conclude that certain SCRES elements have a different effect than expected and therefore should be implemented accordingly.

5.2 Visibility, Flexibility, Redundancy, Collaboration, Market Position and Social Capital as most useful SCRES elements regarding the energy price as a disruption.

5.2.1 Visibility as a positive influence on the disruptive risks of energy price and its positive interrelationship with Social Capital, Flexibility, Collaboration and Agility.

Visibility on the energy prices paid in supply-chains tends to be high, because indexes about it are available on the internet per product market. Next to that Visibility is described to have a positive influence on price, as a higher visibility on the costs of production of suppliers gives a customer more power to negotiate for a lower product price. But the visibility on energy costs is not very high, as this depends per supplier and should therefore be provided by them. The degree of Visibility on the energy price paid is different than the findings of Mulhall and Bryson (2014, p. 332). Also does Visibility seem to have a positive interrelationship with Social Capital, Flexibility,

Collaboration and Agility, as information is easier shared in a good relationship, it increases the possibility to switch, makes it easier to cooperate and increases responsiveness. All mentioned above means that it is important regarding the disruption in this research.

5.2.2 Flexibility (Supplier) showed to be less supportive in the situation of scarcity due to a higher energy price than when implemented beforehand.

Flexibility only has an influence when it is implemented before a disruption (proactive), which means that for it to be positively influencing the risks, a flexible supply strategy should already be in place when a disruption would occur. The only case in which implementing it may work during a disruption, is when a company has a big market position. The findings are different than described in literature as it is described by Ali et al. (2017, p. 28), to be a concurrent strategy, which should be implemented during a disruption. Therefore, it is not expected to be very useful, as in line with literature, most companies only implement it during disruptions, but it can be when implemented before.

5.2.3 Inventory Redundancy implemented during disruption does not cause competitive advantage, only when implemented beforehand.

Redundancy does not seem to be creating positive results in material availability. It only seems to be helpful when always implemented, and not when the market is already disrupted by for instance the energy price. It therefore seems to be a proactive strategy instead of a reactive strategy as is described by (Ali et al., 2017, p. 28). It is in literature described to help to defend firms against disruptions (Rice & Caniato, 2003, p. 26) by having additional inventory (Christopher & Peck, 2004, p. 8) and therefore having material available, but as described it seems to be a bit more nuanced. It can also not be said that it is completely not useful, as it is when always implemented.

5.2.4 Collaboration (Planning) as an effective SCRES element for the specific risks caused by a higher energy price.

Collaboration is a SCRES element that leads to a competitive advantage in the disruption that occurs due to the higher energy price. Especially the collaborative planning is in this research showed to be contributing to lower risk of material unavailability. Next to that it seems to have a positive interrelationship with Visibility and Market Position. As was described by Um and Han (2021) it can be a way to share risk and increase functionality in times of disruption. This all shows that Collaboration is particularly useful in decreasing the risks focused on in this research, especially material unavailability.

5.2.5 Market Position and Social Capital as supporting elements, that also have a high direct influence on supply chain risk.

Market Position and Social Capital seem to have a higher direct influence on product price and material availability than expected, are indeed influencing other SCRES elements, like Visibility, Collaboration and Flexibility and are also a bit influenced by the other SCRES elements. As Market Position provides power to switch between suppliers and increases the likelihood of collaboration of suppliers. Where Social Capital increases information sharing and the likelihood of collaboration. This means that they are very useful, and a direct relationship is in place between Social Capital and Market Position and the risks influenced by a higher energy price.

Regarding the research question: "*Which elements of supply chain resilience are most suited to decrease the risks caused by energy price volatility at suppliers of buying firms*?", can be stated that Visibility, Collaboration, Market Position and Social Capital are in this research found to be the most suited.

6. DISCUSSION

Building on the conclusion of this research described in the last chapter, some academical and practical implications can be given. Also, will the limitations of this research and how future research can enhance this be described in this chapter. This is done to fill in the research gaps described in the Introduction of this research.

6.1 Academical contributions of the findings on SCRES elements and energy as a disruption

Drawing from the conclusions of this research, nine specific academical implications can be made, either enhancing existing literature or questioning it.

The cost of energy is becoming a more important factor in the cost of manufacturing, as it is influencing the raw material price and the manufacturing cost of the company itself. It therefore influences the product price from two sides. Some suppliers even state to be dependent on energy for their business, where when the prices increase, this creates a problem. This matches what was said by Bijnens et al. (2022, p. 38).

The disruption caused by the spike in the energy price in 2021/22 is a supply chain disruption that must be approached in a specific way, because it has a global impact (Ozili & Ozen, 2023, p. 16), is influenced by other macroeconomics, like Covid 19 (Ozili & Ozen, 2023, pp. 2-3) and the war in Ukraine (Ozili, 2022, p. 13) and also influences other triggers of disruptions, such as force majeures (DuHadway et al., 2019, p. 184), by increasing the cost of production so abruptly, that supplier could not bear it anymore. All these things are both showed by literature as by this research, which causes SCRES elements to work and influence differently than described in literature, which means another approach could help and current literature shouldn’t be followed blindly. An approach could be to focus more on Business continuity-inspired resilience (Namdar et al., 2021; Zhalechian et al., 2018), as the availability of products is shown to be the biggest impact by the high energy price and business continuity-inspired resilience focuses on how to be able to keep producing even though going through a disruption. This could align better with the special needs of the approach of an energy price disruption and should therefore also be considered with other disruptions.

Material availability was much more important in the disruption of the energy price, than a rising product price. From my perspective this is about the fact that most of the supply-chains and definitely the b2b supply-chains were just able to charge a higher price to their customers. Looking at the research of (Ganapati et al., 2020, p. 305), this might be true, as they state that 70 percent of the increase in costs due to a higher energy price are passed on to the customer. Grasping back to supply chain resilience it is logical that when the disruption's impact is big enough, companies will focus on survival and therefore prioritizing material availability. The amount of impact therefore might influence whether product availability will be prioritized or not. Market Position could also have an influence here, as a better Market Position could mean that a company can more easily charge higher price. Also, because customers would have a choice when the impact of the disruption is for instance not global, as some suppliers might be cheaper. When availability becomes more important than price and in what situations is interesting for future research.

The fourth contribution is that it should be considered that the energy price should be put in the pandemic-oriented group of risks that is described by Alikhani et al. (2023, p. 1). As its scale is huge and it affects whole supply-chains and not only nodes as described in the conclusion.

The Visibility on the energy price seems to be higher than expected, as indexes can be found on the internet. This opposes what is said by Mulhall and Bryson (2014, p. 332). A problem that does occur in Visibility is the fact that all companies act differently when considering the share of energy in their costs, as for instance transport differs per supplier, which depends on energy (Milewska & Milewski, 2022, p. 1). This decreases the visibility on the cost that the energy price creates and therefore the impact it has. This means that in literature the emphasis should be put more on how the impact of the energy price could be monitored by supply-chain members to decrease the risks of it.

Flexibility and Redundancy seem to only grant competitive advantage when implemented before the disruption, therefore being a proactive strategy. This means these strategies should be always implemented, to work for these kinds of risks, as supply chain disruptions cannot be predicted. For literature on SCRES and supply-chain disruptions, this might mean that also other elements in SCRES literature need to be put in other categories. Especially in situations where abnormal scarcity in materials consists in the market and causes suppliers to implement quotas and only deliver to existing customers. This is different than stated by Ali et al. (2017, p. 28) as they say

they are concurrent strategies. Yet, Tang and Tomlin (2008, p. 15) and Wallace and Choi (2011, p. 285), seem to agree to them being proactive strategies.

Collaboration decreases the specific disruption risks of this research and has a positive interrelationship with other SCRES elements, such as Social Capital and Visibility, which is in line with literature (Cao et al., 2010, p. 6617; Daugherty et al., 2006, p. 62; Faisal et al., 2006, p. 545; Jüttner & Maklan, 2011, p. 254; Mentzer et al., 2001, p. 8; Scholten & Schilder, 2015, p. 480). Especially Collaborative Planning was found to have a positive influence on the material availability. Which means that it is very applicable in times of scarcity.

Social Capital and Market Position can indeed be seen as direct influences of competitive advantage and therefore are indeed SCRES elements like described by Ali et al. (2017, p. 27). Social Capital in the perspective of this research is definitely positively influencing the price, where in a normal context it might maybe negatively influence it. As stated by an interviewee: *"In the case of [company name] for example, we really looked at the relationship. You may know that we have also made less turnover or profit, than we need as a company on the deliveries for [company name] of last year*. To that should be added, and more attention should be awarded to, the fact that they also complement other SCRES elements as proven by this research. Future research could contribute by focusing on this and trying to define the influence Social Capital and Market Position specifically have.

Another contribution is that Supplier Flexibility does not seem to influence Social Capital. It is shown to not be needed to influence it, as the market is so transparent and volatile, that suppliers understand when a customer diversifies its risks. This is opposed to the findings of Johnson et al. (2013, p. 330). Research on Supply-Chain Resilience should therefore focus more on the interrelationships between SCRES elements, as they can have an impact on the implementation and effectiveness of other SCRES elements. As was also described by certain literature like, Faisal et al. (2006, p. 545); Johnson et al. (2013, p. 330); Scholten and Schilder (2015, p. 480), on which can be build further to get to know more about the interrelationships between SCRES elements.

6.2 Practical implications: implementing the findings of this research to increase competitive advantage.

Resulting from this research, companies should be advised on how to approach the risks of an increasing energy price and other disruptions in general. Also is it helpful on bringing the energy price as a disruption to the attention of buyers in practice.

One implication for practice is that Social Capital and Market Position are two very important factors and strategies to decrease the risk of a disruption. As described by Kalafatis et al. (2000, p. 43), companies could personally approach suppliers, control market developments and show longevity of presence in the market to exploit their market position. A company can also focus on relationships with suppliers and thereby increase their Social Capital, by for instance hosting events for key suppliers and implementing interaction protocols for employees, so that long relationships are maintained with attention.

Visibility and Collaboration should also be considered as important strategies to reduce the risk of disruption caused by a high energy price, especially collaborative planning, and information sharing. An annual demand planning is a perfect example of a combination of both, in which you share information to try to align production. Also, should companies exchange information as soon as possible when a problem occurs, as there are negative effects when managers wait with this. Internal strategies can also be aligned when information is shared on a standard base.

Next to that, Contingency Planning should also be implemented. Buyers should together with suppliers look to reduce the usage of products and resources that contain supply risks. Doing this together with suppliers increases the effectiveness as they have more knowledge about that side of the market.

Flexibility and Redundancy are also proven to have a positive influence, only should companies be keen on that it should be implemented before a disruption occurs, as it will not gain competitive advantage when implemented during. This means that it should be implemented at all times, which imposes a high cost of which is not known if it will be earned back (Sheffi & Rice Jr, 2005, p. 44). Regarding the case company it is known that this is for them not a strategy they can implement, as it is too costly and there is not enough warehouse space, which I can expect to be the same for other companies. Flexibility can be increased by maintaining a dual/multiple supply base, by always dividing your supplies between multiple suppliers.

How buyers look at Social Capital, should also change as is found in this research that it has certainly an influence on price increases in times of disruption. This is different than what buyers described, as they only said that it would increase prices. They should therefore change their opinion on Social Capital and invest more in a good relationship to be able to get lower percentages of price increases in times of disruption. How they can do that is described before.

6.3 Limitations and Future research: increase sample size, change roles interviewees, and widen focus of research.

This research has five specific limitations, these are the sample size, role of interviewees, that only one supply-chain is researched, the focus of this research and the exclusion of diminishing energy consumption. These will be linked to how I think it could be enhanced by future research. Next to that some other interesting thing for future research are addressed.

As the sample of this research only consists of 18 interviews, it is almost not generalizable for the complete market or industry, because this number is a bit limited (Rahman, 2020, p. 108). Future research can enhance the findings and make them more generalizable by using a bigger and randomly selected sample. This could also be done by combining it with a quantitative data analysis.

The role of the different interviewees can result in the interviewees having a certain bias as the case company might be an important customer for them. In future research this could be enhanced by asking suppliers to interview a person with high knowledge on the topic, not directly related to the case company. Such as salespersons from a different product line, which also means multiple other supply-chains could be added to the research, which tackles another limitation of this research.

Another limitation in this research is that Social Capital and Market Position were two things that was talked about a lot. This could have skewed the data a bit, because therefore also more results were found on these topics. Future research should try to make the questionnaires in such a way, that all SCRES elements are talked about in the same amount.

Another limitation of this research is that it only focused on the risks of product price and material availability, even though is stated that energy price influences a lot of risks. To get a more clear and complete image on what SCRES elements can best be implemented on the risks caused by an increase of the energy price, future research could try to create a more complete understanding by including the other risks and trying to find out what SCRES Elements work best for that.

The last limitation of this research is the fact that no attention has been paid to the influence of diminishing energy consumption. When thinking about this in a supply-chain, a certain SCRM Culture can be created, in which the consumption of energy is tried to be reduced, or a SC Network is designed in such a way that the energy consumption is as low as possible. These are examples of practices of Robustness and Knowledge Management, which could therefore maybe proof to be of a bigger influence than found in this research.

One thing that future research can really built on is the fact that the literature on the global energy crisis and its implications has rapidly increased over the past year. This means that when this research was started, not a lot of literature was available yet, where much more will be available now. Future research can therefore build on more extensive knowledge on the risks and results of a higher energy price and make a more concise and clearer conclusion of the influence of SCRES management in decreasing these risks.

Next to that, it might be interesting to research the categorization of the SCRES elements in literature, as for instance the findings on Redundancy and Flexibility do not align with literature. An example could be the research by Wieteska (2020), as they research SCRES elements in different stages of a disruption. Also is it interesting for future research to only research the influence of Market Position and Social Capital on the implementation of SCRES elements in practice.

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Appendix I: Questionnaire for Purchasers

Introduction

1. Are there some specific situations that came up during the time of high energy prices (in the last months of 2022,) and could you describe them thoroughly?
2. Where these situations really due to high energy prices and was this communicated to you by the supplier, or do you expect it to be due to high energy prices?
3. Did [company name] really have a standstill in production due to not getting their products?
4. Did [company name] have to decrease their margins due to the higher prices they had to pay for their products?

Strategies implemented.

5. What strategies did you implement as a buying company to act on the problems that occurred, to decrease the possibility of increasing prices or non-availability of products?
6. Can you give some examples of strategies that you currently implement to decrease the risks of such disruptions/problems happening again? For this you can think of all the resilience strategies that I described.

   Follow up questions:
7. You mention …. Could you describe some specific practices or actions you took?
8. In my research I also describe …. as a possible strategy, why did you not implement this?
9. Do you think it would work/would have worked?

Market Position

10. Do you think that the strong market position/financial strength of [company name] influences the risks of price increases or non-delivery of supplier's products?
11. How do you think it influences it? Positively or negatively?
12. Do you also think that it might influence the outcomes of implementation of the other SCRES elements?

Building Social Capital

13. Do you think that partnerships within the supply chain influences the risks of price increases or non-delivery of supplier's products?
14. How do you think it influences it? Positively or negatively?
15. Do you also think that it might influence the outcomes of implementation of the other SCRES elements?

Appendix II: Questionnaire for suppliers

Introduction:

Good morning/afternoon, thanks for agreeing to an interview. I first want to introduce you on my master thesis and the research I am doing for this. I am currently researching what is known on supply chain resilience strategies and how they can help to reduce the specific risks described by my case company. These specific risks are the risk of their supplier increasing the price or not being able to deliver due to high or volatile energy prices. In my literature research I found 13 interesting supply chain resilience elements that could possibly help to do this and to get to know which are the most useful I will be conducting interviews. The interviews with suppliers are done to get a clear view on how the way of doing business changed when the energy prices started to rise, how they think about this from their perspective and how their companies react to change in energy price, for which I made the following questions:

(Disclaimer: with behavior I mean how buyers/customer act towards you and on what things they focus when trying to buy supplies from you)

Introduction

1. Are there some specific buyer-supplier relationship situations that came up during the time of high energy prices (in the last months of 2022,) and could you describe them thoroughly?
2. What happens at your company when the energy prices rise? Which kind of energy is the most critical for your process (gas, electricity, oil, etc.)? Please explain.

3. Is your company dependent on energy for its business? How much energy does your company use per year? (Only to produce your product?)
4. How big of a percentage is the energy price as part of the cost of your product?
5. Can you describe what your company experienced when the energy prices started to rise and when the energy prices were really high?

Behavioural Change

6. How do buyers in general normally behave (act) towards you? Can you describe some examples? (Are they cost-/relationship-/informational-/etc.-focused)
7. How did the behavior (actions) of buyers towards you change? Did they for instance cancel orders or demand changes? (Can you precisely describe what changes you saw in the behavior?)
8. Were there situations in which the change in behavior (actions) of a buyer lead to really problematic outcomes for your company or problems with buyers?
9. Were there situations in which the change of behavior (actions) of a buyer lead to a success or good outcomes?
10. Imagine if a buyer suddenly started to focus very much on ...(strategy)... , how would you have reacted to this? And what could this lead to?

Price

11. Did the high energy prices lead to your company needing to change the prices for your customers? Can you describe the situation you were in?
12. Did you make a difference between prices per buyer/customer? What were the reasons for this? For instance, size of buying company or relationship that was in place.
13. If yes. Why exactly did you change your prices, and did you communicate this to your customers?
14. How did buyers react to these price changes?
15. Did it cause a lot of problems? If yes, what were these problems.
16. How were these problems solved or how where they not solved?

Delivery problems

17. Were there situations in which your company was not able to deliver your products to your customers anymore? Can you describe the situation.
18. If no. How were you able to keep producing and therefore to keep delivering to your customers?
19. If yes. Did you differentiate between which suppliers you still delivered to and which not? (Did you consider market position or a good relationship for this?)
20. How did buyers react to not getting the product they ordered? How did their behavior change?
21. Did it cause a lot of problems? If yes, what where these problems?
22. How were these problems solved? By the buyer or by you?

Appendix III: Literature Research Overview

Keywords/Search filled in at Scopus	**Initial Hits**	**Limit to: 2017-2023**	**Limit to: Subject area: Business, Management and Accounting, and Economics, Econometrics and Finance; Publication stage: final; Document type: Article; Language: English**	**Interesting/Usable**
"Energy dependence" of supply chains	12	5	0	5
How to reduce the risk of supply disruption due to energy dependence	3			0
Energy prices and security of supply	2028	699	97	17
"Supply chain disruption risk"	103	50	17	13
Energy as a supply chain disruption risk	73	50	9	0

High energy prices cause problems for manufacturing firms	1	0		
European energy crisis	1104	496	81	2
Electricity prices as a supply chain risk	43	19	50	
Electricity prices as supply risk	518	236		
Supply chain disruption risks	2272	1478	541	looked through 40
Supply chain risks influenced by energy	26	26	0	0
Supply chain disruptions and volatile energy prices	2	1	0	
Supply chain disruption risk framework	430	288	105	19
Electricity dependence and supply chain risk	12			0
Energy dependence and supply chain risk	55	28	4	0
Supply chain risks under energy price uncertainty	21	12	2	0
Energy vulnerability of manufacturing supply chains	10	8	2	2
High electricity prices in manufacturing firms	3	1	0	0
High energy prices in manufacturing firms	36	12	5	2
Commodity prices and supply chain disruption	0			
Resilience to mitigate disruptions				
Purchasing resilience to decrease supply base risk	0			
"Purchasing resilience"	1			1
Purchasing resilience to mitigate supply risk		1	0	
Volatile commodity price risks				
Energy-resilience	233	191	0	1
Supply-chain resilience strategies	809	679	0	0
Resilience strategies		24649		
Resilience strategies to mitigate supply chain risk	50		14	
Resilience strategies to decrease logistics risks	9		203	

Resilience strategies for logistics risk	163	132		
"Energy price volatility"	75	32		
Effects of high energy prices in supply chains	94	50		1

Appendix IV: Interesting quotations too long for text.

Number	Topic	Quotation
1	"Energy price increase caused low material availability"	"because of course energy strongly influences the market and in particular influences the production of commodities/raw materials. And with that comes several problems: because of the energy rise, many producers reduced their production, thus creating scarcity in products and thus basically making customers suffer more or less as a result".
2	Influence off other macroeconomics on situation in the market/energy price	"So we were thinking maybe we start to slowly improve and the price is bound to go down again, because the prices were at such a high point that we were sure they will go down. So we did not enter into really long contracts at that moment. But anyway, then came another Corona wave and well then we thought, the prices are back at highest level, so we will actually go down. But well, then Corona was kind of over and then the war came and then the energy happened."
3		"Well, here I mean, in general, you know, we have, of course, had a lot of problems with, supply ability and with price increases since the Covid crisis started, you know, in 2020. So it was like our customers, let's say they were kind of used to it, or at least it was not the first time, you know, we had these sudden crises, so they were kind of prepared for this kind of issue happening again."
4		"Of course, energy prices are only a part there and supply is very important in that. Of course also the COVID-19 story, still was there, because we are an international company, as [company name] is also, where you see that that supply and demand, because certain regions came out of the COVID-19 situation earlier than others were completely in imbalance, logistics costs."
5	The material scarcity and price increases.	"But at the time we had to make moves and we did. We really did in six months price increases of 40, 50 per cent. Well, that's really extreme."

		Me: No that doesn't happen very often? “No, no, really not. You see I've been working here myself for 12 years at Wavin , some colleagues have been working for even longer. I've never experienced this before. So extreme and on such short terms”
6	Energy price as a global disruption	“On the other hand, because it was, like I just said, wasn't a Dutch thing, it was a global thing. Everyone was affected by it. Even our customers had to get their raw materials and had to wait for 12 weeks and then I said I have to wait even longer for it, so we were already in the same boat.”
7		“Um, but yeah, I mean, everybody knows it. It's not like this is only in Inabata who has this kind of problem. It's a global problem and everybody is aware of it, our management is aware of it. So, um, yes, we had price increases from our suppliers and some complaints from the customers that they suddenly, especially if you have long term agreements with your customers and suddenly your purchasing price goes up, you have a big problem. But on the other hand, yeah, if the manufacturer cannot supply, you have the same problem.”
8		“I think the whole global market. Because we normal of course, can't imagine that you say: I order, but i do not know for what price and I don't know when it will be delivered. And that is yes a certain acceptance in the market.”
9	Market Position as positive influence on material availability	“That supplier has to make a choice of which customers they are going to deliver the products to. What you see with our top 20 suppliers, is that we are a big customer with all the suppliers and that is of course important, because they often look at their biggest customers first.”
10	Collaboration positively influencing Social Capital	“And in the end, yes, a long-term collaboration and win-win that's key on the long-term. I think it is not anymore that we want to squeeze out suppliers for the last dime, but you want more to a long-term collaboration”.