The Impact of Automating Procurement Tasks on the Resilience of Supply Chains

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ABSTRACT: **Industry 4.0 and task automation can have a huge influence on supply chain performance. While automation is widely recognized for its profound effects on operational efficiency, its specific implications on various areas of supply chain resilience are not explored. This study aims to bridge this gap by examining how the automation of procurement tasks influences the defining elements of supply chain resilience. Using A mixed-methods approach is used that combines literature review with primary data collected through a survey administered to procurement professionals. The literature review establishes a comprehensive theoretical framework by defining procurement, detailing task automation, and the concept of supply chain resilience. This framework then informs the formulation of specific hypotheses that guide the subsequent data analysis. The research categorizes procurement tasks into four key disciplines: Risk Management, Strategic Sourcing, Supplier Relationship Management, and Operational Efficiency. For each of these disciplines, distinct hypotheses are tested to ascertain which supply chain resilience factors are most significantly affected by automation. The findings suggest that automating tasks within Risk Management and Strategic Sourcing can positively enhance supply chain resilience. The impact on Supplier Relationship Management and Operational Efficiency is weaker but still suggests that benefits can be gained from automation but also indicating areas that warrant further in-depth investigation. This study offers valuable practical contributions by providing actionable insights for organizations aiming to leverage automation in procurement to strengthen their supply chain resilience, thereby preparing procurement professionals for the evolving landscape of Industry 4.0. Despite certain limitations, primarily related to the sample size, this research contributes to a better understanding of the intricate relationship between task automation in procurement and contributes to existing literature**

Keywords: Supply Chain Management, Procurement, Automation, Resilience, Industry 4.0

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During the preparation of this work, the author used Google Gemini in order to Check grammar and aid in writing the Abstract. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

1 INTRODUCTION

Industry 4.0 (I4.0) related technological developments have had a profound impact on operational efficiency of companies, a trend that is especially reflected within the manufacturing industry. According to a McKinsey report, it was found that when applying I4.0 technologies, companies could substantially improve their efficiency in key areas such as factory output, productivity and even manufacturing related cost reduction. Out of these technologies, Automation the one with the strongest link to increases in efficiency. Applied in physical or digital form, automation is the process of using technology to imitate human behaviour. Examples include robots for mechanical tasks, or software for automating mundane, standardized and rule-based business processes (Flechsig et al., 2022, p. 1).

A common of focus for literature on Industry 4.0 and automation is procurement, with literature even coining the term "Procurement 4.0" (Joseph Jerome et al., 2022, p. 222). This company department is in charge of acquiring everything a business needs to operate (Young, 2024) giving, decisions made within procurement tasks can have great power over the performance of a company, especially that of the supply chain. A common metric used by literature to assess supply chain performance is supply chain resilience (Joseph Jerome et al., 2022, p. 225).

However, while Supply chain resilience is commonly researched (Qader et al., 2022), its effects are rarely applied to industry 4.0 while highlighting specific areas of supply chain resilience (Rejeb et al., 2018, p. 77). Therefore, despite the prominence of I4.0 technologies in literature, automation specifically and the effects it may have are not explored in terms of supply chain resilience. This thesis aims to investigate that research gap, with the goal to better understand the challenges to supply chain resilience, specifically when automation is applied to procurement tasks. To reach that objective, the following question has been formulated:

"*What is the impact of automating procurement tasks on supply chain resilience*"

With answering this question, the thesis highlights what procurement tasks impact what areas of supply chain resilience and how this relationship is impacted by task automation. This in turn provides insight into where and how task automation is best applied. Contributing to literature by addressing a literature gap as well as providing company managers with understanding and insight into task automation and supply chain resilience.

The thesis starts with literature review, where concepts get defined along with the introduction of literature. This starts with explaining procurement followed by task automation. Then supply chain resilience gets introduced, ending this section by relating everything back to the research question to form hypotheses. This logically leads into the methodology which includes explaining the research method, data collection as well as data analysis. The next section, results includes descriptive as well as statistical analysis and testing of hypotheses ending with analysis of automation data. The discussion then connects the individual analyses from hypotheses and automation to answer the research question. This is followed by exploration of literature contribution with reference to specific literature used. Finishing off with practical contributions. The last section highlights limitations of this thesis and identifies potential future research and how the limitations can be addressed.

2. LITERATURE REVIEW AND THEORY

2.1 Procurement Tasks and Disciplines

The tasks procurement professionals have, depends highly on the industry in which they work. For instance Sjodin et al. (2023, p. 4417) highlights that procurement can differ greatly when focusing on products or services. Therefore, understanding how and where I4.0 technologies can be applied is crucial for companies to succeed. This part will therefore start by introducing what procurement tasks and disciplines are. Within academic literature, no set list of overall procurement tasks that a department does is defined. Explanations tend to focus on procurement and elaborate on tasks in their specific context. The most general definition of what tasks in procurement are, would be: the things that need doing to acquire everything needed to operate the business (Young, 2024). While this definition is from Investopedia and not an academic source, it still highlights the idea that a diverse range of tasks fall under the different disciplines of procurement. Therefore, in this thesis, a set of Procurement disciplines will be defined in part 2.4 hypothesis building to investigate the research question on Supply chain resilience. However, the research question also requires defining specific procurement tasks for investigating automating.

2.2 Digital Task automation and Automating Procurement

The automation of tasks, also called Robotic Process Automation, is an advanced technology used by companies. It allows for the autonomous execution of digital tasks like business processes using predefined steps based on rules (Viale & and Zouari, 2020, p. 3).

Flechsig et al. (2022, pp. 1, 5, 7) highlighted key areas where automation can be beneficial within Supply Chain Management and Procurement. It was identified that logical, repetitive, rule-based tasks are prone to human error. Flechsig et al. (2022, pp. 1, 5, 7) therefore argued that automating these types of tasks could lead to benefits, specifically in these 5: Promoting IT infrastructure, Operational efficiency, Quality improvement, Cost savings, as well as Employee satisfaction. To operationalize research about Task automation, different levels of automation need to be understood. This means a scale for automation is needed and definition of what each "level of automation" will entail. While there is no universal scale for the level of digital task automation a general Human does everything to Computer does everything scale can be used. One of these has been created by Endsley and Kaber (1999, p. 463) A table with the scale is in Appendix A

Referring back to the research question and goal of the thesis, procurement decisions and automating the process of making decisions, can impact the overall performance of a supply chain. An Important measure of performance is Resilience.

Exploring different types of digital task automation would massively increase the scope of this thesis. Therefore, only the general idea behind what gets automated and any consequences from this are looked at.

Classification	Driving Power	Interdependence	Description
Linkage	High	High	Act as intermediary. Represents processes and decisions within tasks
Independent	High	Low	Acts as foundational factor, that other factors build upon. Represents base for procurement tasks
Dependent	Low	High	Represent desired outcomes for processes and decisions
Autonomous*	Low	Low	Do not interact with anything

Table 1: Classification Definitions

2.3 Supply Chain Resilience and its Defining Elements

Resilience of a supply chain is its ability to deal with temporary disruptive events and recover from them Soni et al. (2014, pp. 4-16). The topic of Supply Chain Resilience (SCRE) has become an increasingly common focus of within Literature (Qader et al., 2022). Pettit et al. (2019, pp. 62-63, 56) recognized the importance of SCRE due to its close relation to Supply Chain

Performance. They also state in their paper that the concept initially gained relevance in the early 2000s and has now become essential to supply chain management as a whole. Additionally, they reflect that their 2010 paper on the topic became one of the most cited papers of the decade. Overall, SCRE should therefore be recognized as a central element of Supply Chain Management with high relevance for further investigation. For this thesis, SCRE itself is used as a Concept. However, to investigate the research question and to find the "Impact on supply chain resilience", the concept must be broken down into individual aspects that together make up SCRE. Defining a comprehensive list of quantifiable factors that together define all parts of SCRE allows conclusions to be drawn on exactly how resilience of a supply chain is impacted.

In an extensive literature review, Pires Ribeiro and Barbosa-Povoa (2018, pp. 118, 120) found that overall, authors tend to have different approaches of quantifying aspects of SCRE within research. In most of their identified papers, researchers created models this. However, a majority of these models did not create single comprehensive SCRE Index that can be used for assessment of the whole supply chain. Being able to extract 48 different aspects of SCRE, which they named "Resilience Factors". In the context of this thesis, using factors from these models will therefore not be useful as that is too many to be useful. In addition to not being comprehensive the different papers also tend to be focused in a specific area company. This means the factors can be fairly specific, making them less useful for this thesis since the focus is on a broader manufacturing context

Pires Ribeiro and Barbosa-Povoa (2018, pp. 118, 120) also identified papers which create a single assessment index, these are of interest for the thesis. One of these is by Soni et al. (2014, pp. 4-16). The model since been built upon to in Jain et al. (2017, p. 6780), where 13 different factors are identified (which they call enablers of SCRE). This model is used in the thesis. The enablers are shown to be interdependent of each other and useful for measuring SCRE. Jain et al. (2017, p. 6779)s model works by defining resilience as the capability to deal with temporary disruptive events. The enablers are then used to describe how readiness, as well as response and recovery can be secured Jain et al. (2017, p. 6780). To formulate their list, they began with taking a previous paper by Soni et al. (2014, pp. 4-16). In it, extensive literature review was done to identify 14 factors for SCRE. Next a survey was conducted. With it, knowledge from supply chain professionals was used to narrow down the list and create a single index model to quantify SCRE Soni et al. (2014, pp. 4-16). Jain et al. (2017, p. 6794)s newer model then used rigorous statistical tests to fist identify relationships between these enablers and to then validate the model, resulting in a list of 13 factors Jain et al. (2017, p. 6783). Overall, the findings were found to be reliable, representative and reflective of the views of both big and small organizations Jain et al. (2017, p. 6779) . The model is therefore ideal for use in this thesis. The final list of all factors along with a definition is shown in Appendix B. In this thesis factors are also referred to by their number in the table using F_i (ex: F_1= Adaptive Capability)

The use of this model over others that were identified can be explained simply. Soni et al. (2014, pp. 4-16) among the only ones which created a single Index for supply chain resilience assessment(reference for og paper). Jain et al. (2017, p. 6780) then iterates on this by developing a hierarchical model and thoroughly testing it. Making this model the most qualified to be used in this thesis.

Like mentioned, the factors have been shown to be interdependent, however this is not equal. Some factors are stronger than others in terms dependence and influence over others. To briefly explain, the model classifies every factor as a Dependent, Independent or Linkage variable based on its level of Driving power (Influence) and Interdependence. The classifications are described in Table 1. As a result, when investigating SCRE, the classification of each factor needs to be considered when drawing conclusions. This is further explained in part 2.4 Hypothesis Building along with what classification each factor got.

Hypotheses are required to investigate the research question of this thesis. They will be formed and justified based on logic found in literature and supported by the SCRE framework created by Jain et al. (2017, p. 6780).

2.4 Hypothesis building

Schoenherr and Mabert (2011, pp. 215, 222) explain how a decision within a single procurement task often influences a number of procurement goals. It is highlighted how all, important procurement goals can be grouped together into a set of overriding themes. For example, the theme of Supply security includes goals like risk reduction, collaboration and securing of supply. It can therefore be said that the Supply security theme task can be defined using the 3 listed goals. Extrapolating from this and referring back to the list of 13 SCRE factors, together they define resilience in of the entire supply chain, and a selection of factors can define resilience in a specific Procurement discipline.

To operationalize and investigate the research question, it needs to be determined which SCRE factors are affected by decisions made within in what procurement discipline. In other words, it means defining which SCRE factors define resilience in what Specific procurement discipline. This formulated with, 4 sets of hypotheses are based on literature. Each discipline has a null hypothesis stating that, for [this task] the average importance of selected of factors is not higher than the average importance of the remaining 13 factors. Essentially meaning that the factors do not define resilience in the procurement discipline. The Alternative hypothesis will therefore be for [this task] the average importance of factors is higher than the average importance of the remaining 13 factors. Which means that the factors hypothesised from literature do infect define resilience in the given procurement discipline.

This will allow investigating the research question by then finding out how task automation affects a Specific procurement discipline and in turn the effect on related SCRE factors. Something that will then allow drawing conclusions on how automation will affect the SCRE factors of the task. For each task, one hypothesis is then formulated on the relationship between the task and its SCRE factors.

Overall, it is important to mention that the procurement disciplines formulated here are not exhaustive and do not represent all aspects of procurement. Formulating them is part of operationalization and required to investigate SCRE and task automation. The formulated tasks simply represent areas where the most supply chains resilience related decisions are being made.

2.4.1 Risk Management

Using Schoenherr and Mabert (2011, pp. 215, 222) as a starting point, Supply chain visibility (F_{10}) Risk management culture (F_{11}) and Minimizing Uncertainty (F_{12}) can be grouped together to represent the 3 goals by Schoenherr and Mabert (2011, pp. 215, 222). The group can then be labelled as the procurement task of "risk management" to represent the theme of Supply Security.

Rationale behind this, is the following. When comparing SCRE factors with the goals, "risk reduction" stands out as being similar to F_{12}. Minimizing Uncertainty (F_{12}) aims to reduce the unknowns in different areas of a company's operations. These include source and magnitude of risks, threat of supply chain disruption, the degree of exposure to adverse events and even supplier management practices to some degree (Narasimhan & Talluri, 2009, p. 144). Overall representing the goal while also branching out to the goal of "Securing Supply", Risk management culture (F_{11}) acts as the framework to support this on an operational level (Soni et al., 2014, pp. 4-16) while Supply chain visibility (F_{10}) ensures information is available to achieve everything. The latter is also what incorporates the goal "collaboration", since a large part of $F10$ is the interconnectivity of the supply chain (Emon & Khan, 2024, p. 2). Together, the three factors cover the theme of "Supply security", but also go beyond its scope, especially in the area of visibility. For this reason, the group can be labelled as the procurement discipline Risk Management.

Referring to Appendix B, F12 is classified as an independent "driver" variable, it forms the base of this procurement task. F10 and $F11$ are both linkages (Jain et al., 2017, p. 6787). This means resilience factors for this task are made up of a core, that is supported by two linkage factors enabling it. While literature by Emon and Khan (2024, p. 2) also suggests a strong connection between F_{10} and F_{4} (which would be sustainability), the factor is not of strong relevance here since sustainability has more relevance to another task. F_{4} is also labelled as a dependent variable in Appendix B. This means it is more of an objective and therefore part of a different discipline, one that represents more ideas related to F_{4}. Overall, the following hypotheses can be formulated:

Hypothesis H0_1: For Risk Management, the composite mean importance score for Supply chain visibility (F_{10}), Risk management culture (F_{11}) and Minimizing Uncertainty (F_{12}) is lower or equal to the composite mean importance of the remaining 10 factors

Hypothesis H1_1: For Risk Management, the composite mean importance score for Supply chain visibility (F_{10}), Risk management culture (F_{11}) and Minimizing Uncertainty (F_{12}) is higher than the mean importance of the remaining factors 10 factors

2.4.2 Strategic Sourcing

Anderson and Katz (1998, p. 7) defines strategic sourcing as a set of key decisions in the Sourcing process. These start out with defining the overall aim of what a company wants to achieve. Next, plans are made to reflect it in areas like cost of supply, source of supply and total cost of ownership. After this, follows the choosing of a supplier that can provide what is desired. These decisions reflect $F7$ when looking at the definition by Birkie et al. (2017, pp. 507, 509). Additionally, the decisions reflect insights and understandings from F_{8} Soni et al. (2014, pp. 4-16). Next, the following decision is about actual procurement. Here things affecting decision making are: company procedures and skills needed to execute the plan effectively. This again reflects F7 but also F13, with technology acting as an enabler to support decision making and provide capabilities needed to succeed in $F7$ (Srai & Lorentz, 2019, pp. 79, 90). A conclusion can be made with the following hypotheses:

Hypothesis H0_2: For Strategic Sourcing, the composite mean importance score for Supply chain structure (F_7), Market sensitiveness (F_8) and Technological capability (F_{13}) is lower or equal to the composite mean importance of the remaining 10 factors

Hypothesis H1_2: For Strategic Sourcing, the composite mean importance score for Supply chain structure (F_7), Market sensitiveness (F_8) and Technological capability (F_{13}) is higher than the mean importance of the remaining factors 10 factors

For this task, Jain et al. (2017, p. 6787) classify all three factors as linkage variables in their framework. This results in a strong combination. Strategic sourcing is primarily based on key decisions that support company operations and even other procurement tasks (Anderson & Katz, 1998, p. 7). Something that reflects the very meaning of what a linkage variable is. Therefore the hypothesis is both supported by literature as well as logic presented by Jain et al. (2017, p. 6787). When looking at automation, literature typically explores automation using Artificial Intelligence. In a paper about this very topic Li et al. (2025, pp. 5,6,14,15) suggests benefits to automating strategic sourcing with AI. However, it is also highlighted that human decisions should not be fully replaced. This suggests, automation is beneficial to a certain degree, resulting in this hypothesis:

2.4.3 Supplier relationship management

According to Dubey et al. (2019, p. 768) supplier relationship management are the steps and tasks required for communications with suppliers. Specific parts of this are, close collaboration with Partners to ensure success and to build a stable supply chain, reflecting F_2 (Simatupang & Sridharan, 2002, p. 19). Additionally, close relations will result in collaborative learning and superior risk adversity, something closely related to another factor. F_3 enables collaboration to occur in the first place, since effective relationships need to be built on mutual trust (Tejpal et al., 2013, p. 59). Next, the other main factor of Supplier relationship management is F_6. Sharing information is key to successful collaboration between a company and its suppliers (Hollstein & Himpel, 2013, p. 22). The factor is also enabler of something else that Dubey et al. (2019, p. 768) mentions. F_6 will support collaborative learning and in turn F_5 (Lambert et al., 1999, p. 166). For this relationship, the following can be hypothesized:

Hypothesis H0_3: For Supplier relationship management, the composite mean importance score for Collaboration among players (F_2), Trust among players (F_3), Risk/Revenue sharing (F_5) and Information sharing (F_6) is lower or equal to the composite mean importance of the remaining 9 factors

Hypothesis H1_3: For Supplier relationship management, the composite mean importance score for Collaboration among players (F_2), Trust among players (F_3), Risk/Revenue sharing (F_5) and Information sharing (F_6) is higher than the mean importance of the remaining factors 9 factors

Soni et al. (2014, pp. 4-16) classifies two of the factors as Independent/Driving variables. F2 and F6 each build a foundation that another factor builds on. A fact that is reflected by the two other factors F_2 anf F_5 both being classified as Linkage Variables. Overall, the relationship between Taks and factors is exceptionally strong. Something reflected both in literature and logic from the Soni et al. (2014, pp. 4-16).

2.4.4 Operational Efficiency

This last procurement task is a little different to the others. The focus here, is more on strategic objectives. Bienhaus and Haddud (2018, p. 978) State that to achieve efficiency, procurement must collect and analyse data from all parts of the operation. The results can then be used to support efficiency efforts.

From the SCRE factors, those related to efficiency are Adaptive capability (F_1), Sustainability in supply chain (F_4) and Supply chain agility (F_9). Agile and Adaptive operations mean a supply chain has the ability to always function despite disruptions (Adobor, 2020, p. 447), (Ouabouch, 2015, p. 18). Sustainability on the other hand ensures that all resources are used as efficiently as possible (Martins & Pato, 2019, p. 997). All reflecting back to the idea of Operational efficiency.

When looking at the previous tasks, the three were only made up Independent and Linkage variables. The factors here on the other hand, Jain et al. (2017, p. 6787) defined them all as dependent variables. This means they build upon successful implementations of the previous tasks to support efficiency, just like how it is done according to Bienhaus and Haddud (2018, p. 978). Therefore the Relationship between Task and SCRE factors is strong both according to literature, as well as logic presented by Jain et al. (2017, p. 6787). It can be represented with this Hypothesis:

Hypothesis H0_4: For Efficient and Robust operations design, the composite mean importance score for Adaptive capability (F_1), Sustainability in supply chain (F_4) and Supply chain agility (F_9) is lower or equal to the composite mean importance of the remaining 10 factors

Hypothesis H1_4: For Efficient and Robust operations design, the composite mean importance score for Adaptive capability (F_1), Sustainability in supply chain (F_4) and Supply chain agility (F_9) is higher than the mean importance of the remaining factors 10 factors

In the thesis, the hypotheses are also referred to by their number. For conciseness, "H1" will refer to both the Null as well as the alternative hypothesis for risk management together, unless explicitly stated otherwise. A visual overview of the hypotheses is shown in Figure 1

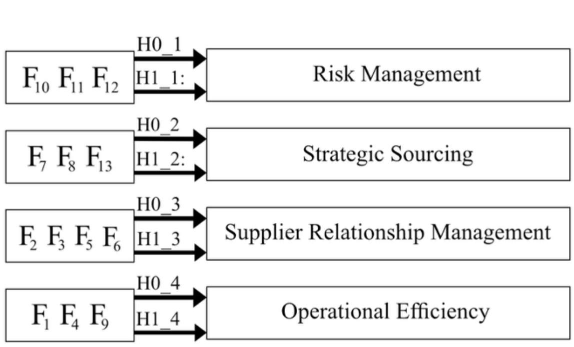

Figure 1: Hypothesis overview

3 METHODOLOGY

3.1 Research Methodology

The formulated research hypotheses must be tested investigate the research question. Rejecting or not rejecting the null hypotheses determines if a supply chains resilience factor is impacted by decisions made in specific areas of procurement or not. The alternative hypotheses will allow a direct connection to be made between a procurement tasks and specific aspects of supply chain resilience.

Testing the research hypotheses is done with a statistical analysis using primary qualitative data collected from a survey. Formulating the survey questions starts with literature research, this is further explained in Section 3.2 Survey design.

The specific statistical test is explained in section 3.4 Analysis, but the logic behind how results are used is as follows. Testing a null hypothesis involves calculating a p value and choosing a significance level. Running the statistical test on the data, will provide a test statistic along with its P value. In the case of this thesis, the test statistic will show if more survey responses have importance of other SCRE Factors lower than the hypothesised SCRE factors, which would support the alternative hypothesis or not. The p value then shows the statistical significance of this value. From this each of the Null hypotheses can then either be retained or rejected.

If the null hypothesis gets rejected, the connection between Procurement tasks and SCRE factors can be used to answer the research question. For this, qualitative data also gets collected on automation. However, results of this are analysed descriptively and with the help of research from literature. Overall, this approach allows answering the research question with qualitative literature research and quantitative primary data collection.

In literature, this is considered a mixed-methods research approach, where qualitative and quantitative methods are combined in the same study (Denzin & Lincoln, 2011, p. 262). For this thesis, the exact method builds on the research design by Collins and Stockton (2018, pp. 2, 6, 8). In essence the design enables theories and information from literature to be used when analysing results from qualitative research. The idea is to implement a theoretical framework which consists of existing knowledge, formed ideas and research about complex phenomenon. This then acts as a lens for analysis of data to draw conclusions, similar to this thesis. For it, initial literature research is done for this to formulate the hypotheses and survey question, research then also acts as a "lens" to analyse survey data. Qualitative research tends to be complex and highly contextualized, therefore this lens can also aid in transferring findings to another setting while also making the overall analysis more explicit and objective. Collins and Stockton (2018, pp. 2, 6, 8) visualized the design with a diagram, this is in Appendix C

Reason behind using this quantitative approach is that it allows for larger sample of data, since collection is less time intensive than qualitative interviews. Additionally, the research does not require detailed answers, a typical reason for using interviews. Overall, this method will also provide balanced research, that gives a comprehensive result while accounting for potential bias. The applied method is visualized in Figure 2 Research Design Diagram:

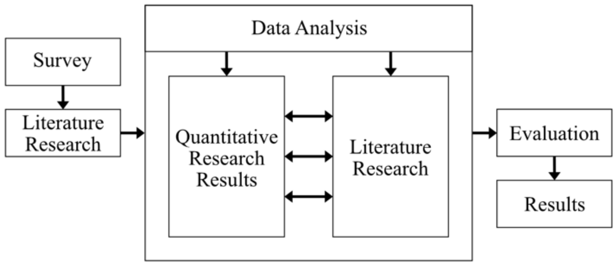

Figure 2 Research Design Diagram

3.2 Survey Design

Because it is the only method primary data is collected for this thesis, operationalizing the research question and formulating effective survey questions is crucial. The survey consists of 3 main parts. The first acts as an introduction and will inquire about the person, while ensuring that answers will not give away sensitive information. Also ensuring answers from the survey will provide useful responses. Responders have to be knowledgeable about the topic for their answers to be relevant, therefore, the first question will inquire briefly about the qualification of the responder. This is done by asking them to state their role within the company, as well as what the company does. The amount of "Qualified" responders can therefore be determined to assess the quality of the data. Additionally, the survey will mainly be sent out to people that work in supply chain management.

The next part is about SCRE factors and Procurement tasks. It is comprised of 4 questions, in each the responder is presented with a list of all 13 SCRE factors. The question then reads "For [Procurement Task] which of these items is significantly important?". This repeats for all for Hypothesis, meaning for 4 different procurement tasks. Presenting all 13 factors for each of the disciplines like this ensures objectivity when investigating Hypothesis 1-4. The person is not aware of which factors are hypothesised to be relevant for which discipline. Also, it provides more nuance and gives insight into the interconnectivity of factors. Additionally, this provides a level of redundance, to test for answer continuity. According to the hypotheses, factors are essential for one of the disciplines, the importance rating should then be high for one of them and lower for the other disciplines. This is further explained in section 3.4 Analysis.

The last part is about Automation and has one question. The design of this question is based on what was established in the literature review. There is no set list of tasks that are done in procurement. The four 4 disciplines that were identified to have an impact on SCRE are too broad to be used in a survey question like this. Inquiring about task automation needs more specific logical tasks related to these disciplined. The question therefore uses two procurement tasks for each discipline. Together, the tasks make up all major parts of their respective discipline. While the tasks are also not overly specific since they still have to cover multiple areas, it is a good middle ground between too general making it not focused enough and too specific making it too complex for a survey The question then reads: "Considering these Procurement tasks, which level of automation will result in the most optimal decisions being made?". The person will also be given a short definition of what SCRE is. They then rate the level of automation that would result in optimal decision making for a selection of tasks. More explanation follows in section 3.4 Analysis.

For the second and third part, answers are given using a 1-7 Likert scales. This allows results that are neutral as well as high or low while providing more nuance the 1-5 scale wouldn't. On the other hand, answer options are also limited enough so that intervals between scale points are still large enough to encourage thoughtful decisions unlike in a 1-10 scale. A breakdown of what tasks were selected represent each procurement discipline is in appendix D

3.3 Sample

The sample consists of everyone who has answered the survey. As part of the research process the survey was shared with as many qualified people as possible. To begin with, individuals on the platform LinkedIn working in supply chain management. Here individuals were directly contacted and asked to fill out the survey. Additionally, a link was shared on a LinkedIn survey exchange group, and a university professor shared it on their profile. The other main source of responses were individuals who attended a Workshop on supply chain management. Here all attendees were sent an email asking them to fill out the survey after the workshop.

The amount of survey responses is very low. Overall, only 25 people opened the survey and just 11 people actually provided a full response. As a result of this, the sample size will not allow for things like regression analysis since generally this would require at least around 50 responses to result in something that can be considered statistically significant.

3.4 Analysis

For analysis, survey data will be processed using the software SPSS. To start, the data needs to be cleaned, and incomplete survey responses are removed. Next the data needs to be checked for statistical significance. More specifically in the case of questions about SCRE factor importance, it needs to be tested if the 1-7 ratings given for each question have a statistically significantly difference from one another. This means the test will answer if it is possible to treat answers as individual or if survey answers were purely random. This is done with a Friedman test, a statistical non-parametric test used to compare data from at least 3 different groups. For the survey results on factor importance, each of the 13 factors will receive a mean rank of that states the importance to the Procurement task in question. Data from the four questions (or groups) is then compared. After this a P-Value is given, which will determine statistical relevance. (Significance level used is $p< 0.05$)

The next step is to test for the hypotheses. Starting with Risk Management, a Nonparametric test evaluates if the importance rating given to the factors from the hypothesis have a statistically significant higher value when compared to the other non-hypothesised factors. The result will then provide the answer on if survey data supports the hypotheses or not. The ideal test to use in this case is the Wilcoxon Signed Rank test. The reason being that it compares two related samples.

To run this test, the data needs to be processed two variables that can be used as input. For each of the disciplines, one variable representing the scores of the hypothesised factors and one for representing the remaining factors. Overall resulting in 8 Variables. Data processing and the forming of the variables works by creating Composite scores for the median score given to hypothesised factors (e.g. D1_Median) and the median score given to the remaining factors (D1_Median_other). After repeating this for all 4 procurement disciplines, the variables can now be put into a Two Related Samples Wilcoxon Test in SPSS. D1_Median for Variable 1 and D1_Median_Other for Variable 2.

The specific reason behind using median is that the original data is ordinal and medians are the most appropriate method of compositing ordinal scores. However, the most important reason for using medians is because of the small sample size. Averages are much more susceptible to outliers in small samples. Medians provide a more robust composite score for each factor. If the test determines that for example D1_Median has a statistically higher score than D1_Median_other for most of the responses, the Null Hypothesis can be rejected.

Automation does not have a hypothesis and is also not tested using a statistical test. The main way this data is analysed is using descriptive statistics and extensive literature research. Oger et al. (2018, pp. 1505-1508) proposed a framework for automating the steps of risk management. In it, data and information will automatically be gathered from the whole supply chain and from all stakeholders. Next, an algorithm can then deduce all scenarios and options that relate to current objectives and events. The objective of the Framework is explained as aiming to provide support for strategic decisions. Therefore, it can be understood, that increasing the automation in Risk Management will lead to improvements in SCRE and that a task must have an optimal level of automation which will result in the most possible resilience. Extrapolating from this, if the alternative hypotheses about factors defining resilience in procurement disciplines stand. Data on automation can then be used along with literature research to understand how information will impact the specific factors. The 1-7 ratings for "level of automation" will be based on the 1-10 scale by

Procurement Discipline	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	P -value
Risk Management	7,18	5,73	4,95	3,95	6,18	5,59	8,55	6,18	7,86	9,59	11,00	9,32	4,91	<0,001
Strategic Sourcing	6,73	6,68	6,05	5,45	5,64	6,00	10,00	8,77	7,32	7,00	5,14	6,27	9,95	0,003
Supplier Relationship Management	4,68	10,23	10,45	6,32	9,23	10,36	5,77	4,59	6,32	7,14	5,18	5,45	5,27	<0,001
Operational Efficiency	10,14	6,73	7,18	7,91	5,14	6,45	8,23	5,36	9,64	7,45	6,45	5,50	4,82	0,003

Table 2 Friedman test

Endsley and Kaber (1999, p. 463) in appendix A. Because the data is not normally distributed, ordinal and the sample size is small, median values are presented. These are more robust against outliers.

3.5 Usability of data

The survey was answered exclusively by individuals who have identified their job to be within the supply chain management. Answers can therefore be considered to come from "Qualified" responders. All given job descriptions are in Appendix E (Specific information was anonymized). Due to the small sample size, it needs to be tested if the data is usable and if differences between factors scores are statistically significant or if data on the factors cannot be treated individually. Essentially testing if the data is random or if trends exist. This can be done using a Friedman test, a non-parametric test used to compare differences between medians of related samples. Essentially comparing the Importance scores within each response ratings and then comparing across all responses. The result of which can be seen in Table 2

F are the Mean Rank for each factor for the discipline. The P value will determine if difference in importance of the factors is statistically significant. As seen in Table 2, for all 4 procurement tasks the P-value is below the significance level. This means the data can be used since factor scores are statistically different enough to be considered separate answers.

4. RESULTS

4.1 Descriptive Analysis

Analysing the data starts of with descriptive statistics, followed by a statistical nonparametric test to test the research hypotheses. Then the survey data on automation is looked at with conclusions to the research question following in section 5 discussion.

Results from the Friedman test in table 2 can also be used in a descriptive analysis. If the alternative hypotheses are true and factors can be used to define automation in in a Procurement discipline, the data should support thins. For example, H1 states that Factors F10, F11 and F12 together describe resilience in Risk management. If this is true, the three factors with the highest rating for Risk management should be the ones from the hypothesis. A list of the highest rated factors for each task in descending order along with the tasks stated in each hypothesis is in table 3

H	Task, Factors	Survey Result
H1	Risk Management: F10, F11, F12	F10 (11.00), F9 (9.59), F11 (9.32)
H2	Strategic Sourcing: F7, F8, F13	F7 (10.00), F13 (9.59), F8 (8.77)
H3	Supplier Relationship Management: F2, F3, F5, F6	F3 (10.45), F6 (10.32), F2 (10.23), F5 (9.23)
H4	Operational Efficiency: F1, F4, F9	F1 (10.14), F9 (9.64), F7(8.23)

Table 3 – Descriptive analysis

What can be gathered from the data is the following. The median values reflect what is hypothesized everywhere except for H4. In this discipline, F7 is among the 3 factors with the highest importance but it is not hypothesized. For reference, the factor that was hypothesised to be among the three with the highest importance is F4. In the survey data, it had a median score of 7.91, making it the next factor a in terms of importance score in descending order after F7.

4.2 Nonparametric test

Table 4 Shows the results of the Non-Parametric Wilcoxon test. In the table, Negative rank is the number of survey responses where *Median Importance score of remaining factors < Median Importance score of Hypothesised factors.* This means that when asked about Risk Management for example, 9 out of 11 responders ranked F10, F11, F12 with a statistically significant higher importance score as the remaining 10 factors. Only two responders did not do this. In one case the two median importance scores were equal (Ties), in the other the remaining/non-hypothesised factors had a higher median score (Positive Rank). The Z value also shows this numerically, when it is negative, Negative rank is greater that the Positive rank and ties which would support the alternative hypothesis. The P-Value then determines if this answer is statistically significant, if lower than 0.05. This means that based on Z and P values, all four null hypotheses can be rejected and all alternative hypotheses accepted.

Because the sample size of the data is only 11, this limits the statistical relevance of all results. This means, while the P-Value might suggest statistical significance within the test, the data is likely not representative overall. Therefore, drawing conclusions from this data needs to be done carefully and using insights from descriptive statistics to account for this. For the first three procurement disciplines both descriptive statistics as well as the nonparametric test suggest that supply

Procurement Discipline	Negative Rank	Positive Rank	Ties	Z	P-Value	Hypothesis Test
Risk Management	9	1	1	-2.739	0.006	Reject null hypothesis *H0_1* and accept alternative hypothesis *H1_1*
Strategic Sourcing	9	1	1	-2.047	0.041	Reject null hypothesis *H0_2* and accept alternative hypothesis *H1_2*
Supplier Relationship Management	8	0	3	-2.536	0.011	Reject null hypothesis *H0_3* and accept alternative hypothesis *H1_3*
Operational Efficiency	7	3	1	-2.213	0.027	Reject null hypothesis *H0_4* and accept alternative hypothesis *H1_4*

Table 4 – Wilcoxon Test

chain resilience in Risk Management, Strategic Sourcing and Supplier Relationship Management can be defined with the factors F10, F11, F12 and F7, F8, F13 and F2, F3, F5, F6 respectively. For the fourth discipline this is different. In the nonparametric test, Operational Efficiency has the lowest amount of positive rank answers. Three responders rated the importance of factors other than F1, F4, F9 higher than the importance of F1, F4, F9. Resulting in the highest Positive rank out of any of the procurement disciplines. When looking at the descriptive analysis in table 3, Operational efficiency is different from the others as well. The discipline is the only one where the hypothesized factors are not the same as the factors with the highest median importance rating. It is also worth mentioning how for Supplier Relationship Management the average importance of hypothesized factors tied with the average importance of remaining factors for 3 responses. This constitutes around a quarter of all responses.

The data relationship between hypothesised factors was also examined using a parametric test in the form of of correlation tables. However, correlation coefficients were found to be consistently to low to be relevant. The tables are in Appendix G

4.3 Automation

Data for which level of automation is optimal for each procurement task is shown in Figure 3

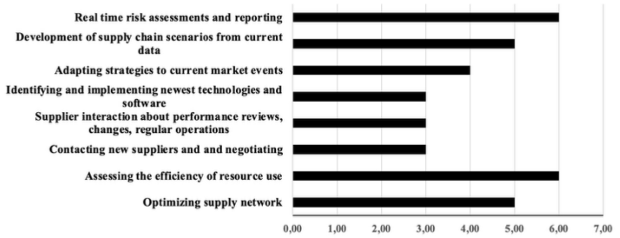

Figure 3 – Optimal level of automation for Procurement tasks

In descending order, two bars represent the tasks within a procurement discipline. The data show that for Risk Management tasks, the optimal level of task automation on a scale of none, to fully automated is 5 to 6 out of 7. Strategic sourcing is lower, with data suggesting 3 to 4 out of 7. The next discipline, Supplier relationship management is the lowest with 3 out of 7. Operational efficiency has a higher suggested level, being 5 to 6. The general trend that can be observed from figure 3 is the following. Tasks that require human interaction tend to benefit less from automation than tasks involving logical processes and decision making. An example of this seen when looking at the disciplines Strategic sourcing and Supplier relationship management. Strategic sourcing tasks like implementing new technologies are less logic based than adapting strategies to current market events, since it might things like involve changing manufacturing methods. A process that may require more creative thinking than analysing market trends and with statistics. In the data this is reflected, with the latter of the two having a lower rating for optimal level of automation. Supplier relationship management also reflects this. Tasks in this discipline inherently require more social interaction and less logical process-based decision making.

5 DISCUSSION

5.1 Answering the Research Question

This research aimed to investigate the relationship between of Automating Procurement tasks and the resulting effect on supply chain resilience. This was done in the context of tasks in four different procurement disciplines.

Section 3.5 tests the useability of data as mentioned, the survey results were provided by people that can be considered qualified. Data was than tested using a Friedman test. For this, results in table 2 state that there is a statistically significant difference between the values. Additionally, the hypothesised factors have been generally confirmed as being the most important for their respective procurement discipline using descriptive statistics like hypothesised. All of this is strengthened by consistently low P-Values which are under the significance level of 0.05. After testing the research hypotheses, the parametric test results in table 4 show that all 4 null-hypotheses can be rejected. This means based on statistics, data from the automation survey questions can be used to answer the research question. However, the data's small sample size limits the strength and accuracy of results from statistical tests and descriptive analysis. Therefore, it is not possible to count out the possibility of coincidences or random chance, meaning individual discussion is required to draw a conclusion for each procurement discipline.

This starts off with the ideal level of automation based on literature, which is then then combined with data from figure 3 moving. Data from table 4 is then used to determine if the research question can be answered for each of the procurement disciplines. Insights from descriptive analysis, which also includes data from table 3 are used to address limitations arising from the small sample size of the survey.

5.1.1 Risk Management and Strategic Sourcing

Looking at automation of risk management tasks, literature describes it as the following: Manual (non-automated) risk management would mean selecting suppliers and considering all possible alternatives while taking all variables into account "by hand" (Narasimhan & Talluri, 2009, p. 144). Therefore, using Flechsig et al. (2022, pp. 1, 5, 7)'s definition, for where Automation would likely lead to improvements, there is potential benefit from automate procurement tasks in this discipline. The survey data reflect this, figure 3 shows that the level of automation is high with a median of 5 to 6 out of 7.

In regard to strategic sourcing, Li et al. (2025, pp. 5,6,14,15) mentions that manually comparing and choosing suppliers is challenging. Procurement professionals may struggle with bias, lack of knowledge and/or human error. Therefore, it can be understood that the SCRE Factors relating to strategic decisions identified by Anderson and Katz (1998, p. 7) can benefit from automation. Furthermore, Li et al. (2025, pp. 5,6,14,15) highlights how automation can drastically improve supplier categorization as well as helping with quick decision making in dynamic, changing environments. However, then clearly stating how automation will compliment and not replace manual work. The survey data reflects this, with

Strategic sourcing related tasks being given an optimal automation rating of 3 to 4 out of 7.

The analysis and hypothesis testing in section 4.2 present a strong relationship between the disciplines Risk Management and Strategic Sourcing and their respective hypothesised factors. Here, both the descriptive analysis as well as the non-parametric test reflect their respective alternative hypothesis. The factors can therefore be used along with automation data to answer the research question

it can be said that based on literature and statistical tests, high to very high automation of Risk Management tasks enables supply chain resilience. In particular with optimal supply chain visibility, risk management culture and minimizing uncertainty.

It can be said that based on literature and statistical tests, strategic sourcing tasks, particularly those related to optimizing current strategies can benefit from high task automation. Enabling supply chain resilience through optimal supply chain structure and market sensitiveness.

5.1.2 Supplier relationship management

Interpreting data on the other two procurement disciplines is more difficult. Starting off with automation, it is not really discussed in literature in the context of Supplier relationship management. However when looking at general literature related to the discipline and Flechsig et al. (2022, pp. 1, 5, 7) paper on automation, gives some insight. Tejpal et al. (2013, p. 59) discussed supplier relationships, stating how they come with an inherent variability. Combining this with Flechsig et al. (2022, pp. 1, 5, 7) definition of where automation could be useful, suggests that usefulness of task automation in this Procurement discipline is highly limited. While the survey results don't present data that completely contradicts this, rating 3 out of 7 as the optimal level of automation does suggest that from the perspective of procurement professionals, moderate automation can provide benefits

When looking at the nonparametric test. While based on Table 4, the null hypothesis is rejected. Supplier relationship management had a relatively high amount of ties, suggesting that responders might have been unsure. Resulting in answers that were random and then coincidentally had a similar mean, or answers that were all very similar. However, due to the small sample size nothing can be said with certainty. But put purely based on survey data this relationship between factors and discipline is weaker than the previous two. It can therefore be said that based on literature and statistical tests, supplier relationship tasks, will enable supply chain resilience with moderate automation through optimal Collaboration among players, Trust among players, Risk/Revenue sharing and Information sharing.

5.1.3 Efficient and Robust operations design

Due to the nature of tasks in this procurement discipline, literature by Flechsig et al. (2022, pp. 1, 5, 7) suggests that high levels of automation could provide benefit. Tasks like assessing the efficiency of resource as well as optimizing the supply network use are highly analytical, meaning automation can reduce the likelihood of error. This is confirmed by the survey data. Scoring 5 to 6 out of 7 for an optimal automation rating.

In regard to the factors, this discipline is different from the others. When looking at descriptive statistics in table 3, it is the only one where hypothesised factors are not represented in the survey data. In the nonparametric data from table 4, this discipline is also the one with the lowest amount of negative ranks. However unlike for the previous discipline, here around a quarter of survey responses resulted in a positive rank. This is also the highest number out of any of the disciplines, something that suggests survey responses varied the most out of any discipline. This in turn suggests procurement professionals were divided on which factors represent this discipline

Overall, it can be said that based on literature and statistical tests, Efficient and Robust operations design, particularly those related to assessing the efficiency of resource can benefit from high to very high task automation. Enabling supply chain resilience through adaptive capability, sustainability in supply chain and supply chain agility

5.2 Literature contributions

Within literature, a distinct gap was identified around the topic of supply chain resilience and task automation (Rejeb et al., 2018, p. 77) . The results of this in section 5.1 help to fill in that gap. The thesis therefore contributes to academic literature in this area.

Additionally, this thesis draws heavily on ideas and concepts developed by Jain et al. (2017, p. 6779). Therefore, literature contribution also expands to contribute to their paper. In the Research implications, Jain et al. (2017, p. 6793) state that future research should quantitatively explore the identified SCRE factors and the strength of relationships. This thesis does exactly that by investigating and establishing relationships between specific factors and applying them to a practical context in the form of a procurement discipline. The paper therefore contributes through relationships hypothesised and investigated.

The factors supply chain visibility, Risk management culture and Minimizing Uncertainty have a relationship in the context of Risk Management

The factors supply chain structure, Market sensitiveness and Technological capability have a relationship in the context of Strategic Sourcing

The factors collaboration among players, trust among players, Risk/Revenue sharing and Information sharing have a relationship in the context of Supplier relationship management

The factors Adaptive capability, Sustainability in supply chain and supply chain agility have a relationship in the context of Efficient and Robust operations design

5.3 Practical contribution

Unted managerial implications, Jain et al. (2017, p. 6793) state "In order to justify the need for resilient supply chains, managers need to have an understanding and clear definition of the phenomenon of resilience". This thesis builds upon that by applying a practical context to resilience. Managers can use the research to gain understanding on which decisions in procurement impact SCRE in what way. Additionally the thesis also builds upon Jain et al. (2017, p. 6779)s paper by applying an Industry 4.0 context with task automation. Managers can use this research as a starting point for SCRE related problem solving when implementing task automation. Or a company can identify areas of SCRE they struggle with. Managers can then use information from this thesis to understand how applying task automation to specific procurement tasks may improve a company's SCRE.

6 LIMITATIONS AND FURTHER RESEARCH

6.1 Limitations

A major limitation of this research is the sample size. Due to the fact that only 11 individuals responded to the survey, the statistical relevance of all findings, as well as the ability to generalize the findings is highly limited. Typically for quantitative research the sample size should be around three times as large to ensure statistical relevance

Another limitation stems from the chosen research Method. Since the primary research was conducted via an online survey, there was no direct interaction with the respondents. Therefore, questions and question descriptions had to be phrased so that they provide all needed information, and the individual fully understands the question they are answering. This means the quality of survey responses is related to the quality of the survey.

For the study, the 13 different SCRE factors which were the core of a large part of the survey. These are related to another limitation. Jain et al. (2017, p. 6786)'s SCRE factors were identified to be highly interdependent of each other.

Because of this, most of the 13 factors were rightfully rated at least 4/7 or "mostly relevant" in the survey. Leading to difference es in survey fairly small (mostly concentrated in the 4-7 range). The survey also did not provide definitions or explanations for each of the factors. Therefore, all information that an individual had to go from when asked to rate which factors are relevant for a certain procurement discipline, were the names of the factor and discipline itself. The issue here is that while with appropriate context or a definition of what "Risk Management" for instance, the selection of what factors are relevant would have been more specific and the data might have provided more significant answers. These provided definitions should have still left room for interpretation, meaning the selection of factors would still come fully from the respondent, but responses might have been more relevant overall.

Lastly, there are potential limitations that stem from the question design itself. Asking a person to rate 13 different factors 4 times in a row in a survey might be considered tedious by some. Resulting in them potentially answering the later questions about H3 and H4 quickly, selecting most things as "somewhere in the middle" and without much thought. Secondly, the clustering questions started off with Risk Management. When first being presented with this task and a list of 13 different factors the person doesn't know that following this, are three more tasks where they do the same rating. Therefore, they might have seen the task and selected a few things that a first thought might seem highly relevant to Risk management, without knowing that the factor might be more relevant to a different task. And it would be unrealistic to expect a person to go back to changing their previous answer. Finally, another major limitation is that it is not stated anywhere that the relevance of the factors should be exclusive. Meaning that a factor is by design only intended to be an essential element in one of the disciplines and then be moderately important in the other disciplines at most.

Some of this was attempted but not able to be solved in the survey design and some of the limitations were a direct result of decisions made to address other possible limitations. For example, choosing to split up the 4 disciplines into different questions was a result of making the survey more mobile friendly and an attempt to get more nuanced results. Initially, the question was designed as drag and drop, where the person was presented with the 4 tasks and then asked to drag and drop SCRE factors into groups, representing the task. This didn't work well on mobile devices so the idea was scrapped in favour of a matrix design, where the person could select one task per factor. However, this meant that a person was forced to split up the factors which might have resulted in uneven distribution between the factors, potentially limiting the usefulness of the data. This is because decisions might potentially be random if the person is unsure of what to answer. If a person now selects assigns a factor to a task this choice has a high weighting in the final data. That's why the 1-7 rating was used, it provides a more nuanced answer. Unfortunately, it also partially leads to the other extreme taking place, where the data might now be too ambiguous.

6.2 Future research

A logical conclusion of what to further research would be continue this study with a larger sample. Due to the insufficient survey responses and the minimal statistical relevance of conclusions,

An area of research that was not addressed in this thesis is different types of task automation. Future research could focus on how a task might be automated and which option would provide the best outcome for decision-making. This could provide procurement professionals with more specific insight into SCRE.

A highlighted limitation of this thesis is the method of data collection. Using a survey and quantitative data collection enabled the testing of concepts and ideas from literature. Overall, establishing a relationship between automating decision-making in procurement and supply chain resilience. However, while a survey allows a large amount of data to be collected in a short time when compared to qualitative methods. Survey answers lack the context an interview answer might provide. For instance, reasoning behind a specific answer, follow up questions or other insight from the interviewee. For this reason, future research should aim for qualitative insights verify and strengthen the findings of this thesis. For instance, testing the findings at manufacturing companies operating in different industries, ensure that practical and literature contributions more representative and generalisable.

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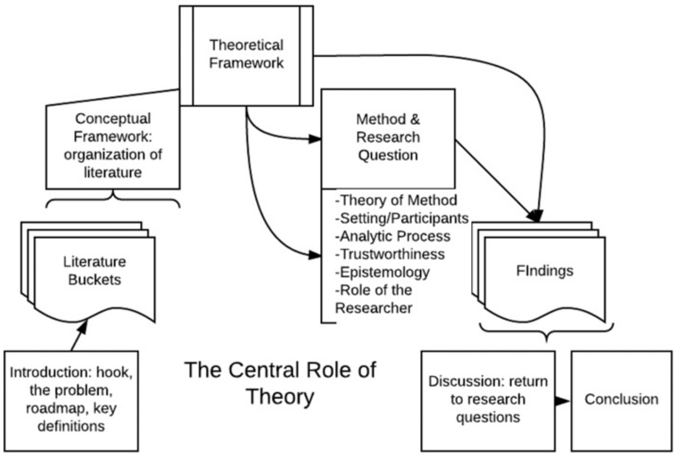
Appendix A Levels of Automation defined by Endsley and Kaber (1999, p. 463)

Level	Definition
1	human does the whole job up to the point of turning it over to the computer to implement
2	computer helps by determining the options
3	computer helps to determine options and suggests one, which human need not follow
4	computer selects action and human may or may not do it
5	computer selects action and implements it if human approves
6	computer selects action, informs human in plenty of time to stop it
7	computer does whole job and necessarily tells human what it did
8	computer does whole job and tells human what it did only if human explicitly asks
9	computer does whole job and decides what the human should be told
10	computer does the whole job if it decides it should be done, and if so, tells human, if it decides that the human should be told

APPENDIX B – Table with list of Factors and Definitions

F_i	SCRE Factor	Definition	Reference
F_1	Adaptive capability	Structural and/or Behavioral processes support adapting to changes	Adobor (2020, p. 447)
F_2	Collaboration among players	The collaborative relationship of independent companies that work together for improved results and mutual benefit	Simatupang and Sridharan (2002, p. 19)
F_3	Trust among players	Entering relationships that are reliable	Tejpal et al. (2013, p. 59)
F_4	Sustainability in supply chain	Sustainability in product design, processes, material use, sourcing and end of life	Martins and Pato (2019, p. 997)
F_5	Risk/Revenue sharing	The process of sharing both risks and rewards with stakeholders, resulting in a competitive advantage	Lambert et al. (1999, p. 166)
F_6	Information sharing	Ensuring everyone on supply chain has access to information about performance and any disruptions	Hollstein and Himpel (2013, p. 22)
F_7	Supply chain structure	Determines the variety and dependencies for components in a system. On a broader scope, geographical dispersion or level of focus on price, quality, speed	Birkie et al. (2017, pp. 507, 509)
F_8	Market Sensitiveness	Capability of supply chain to interpret market demands	Soni et al. (2014, pp. 4-16)
F_9	Supply chain agility	Ability of the Supply Chain to quickly recover from disruptions and survive in uncertain environments.	Ouabouch (2015, p. 18)
F_{10}	Supply chain visibility	Interconnectivity and information sharing along supply chain	Emon and Khan (2024, p. 2)
F_{11}	Risk management culture	Establishing a corporate culture that embraces management of risks outside on a broader scope	Soni et al. (2014, pp. 4-16)
F_{12}	Minimizing Uncertainty	Reducing the uncertainty in source and magnitude of risks, supply chain disruptions, the degree of exposure to adverse events. Includes aspects of supplier management practices.	Narasimhan and Talluri (2009, p. 144)
F_{13}	Technological capability	Level of technological readiness and availability of infrastructure	Srai and Lorentz (2019, pp. 79, 90)

Appendix C : The Qualitative Process by (Collins & Stockton, 2018, p. 8)



Appendix D: Tasks of each Discipline

Discipline	Task
Risk Management	Real time task assessments and reporting
	Development of supply chain scenarios from current data
Strategic sourcing	Adapting strategies to current market events
	Identifying and implementing newest technologies and software
Supplier Relationship Management	Supplier interaction about performance reviews, changes and regular operations
	Contacting new suppliers and negotiating
Operational Efficiency	Assessing the efficiency of resource use
	Optimizing supply network

Appendix E: Responder Profiles

Responder	Role
1	Country Procurement Head
2	[------] Raw Materials Director
3	Purchasing analyst
4	Purchaser of waste [-----]
5	Procurement Managing Consultant
6	purchaser
7	Procurement
8	Supply Chain Analyst
9	Logistics
10	Purchasing
11	Procurement

Appendix G Correlation Tables

Correlations

			Risk Management – Supply chain visibility	Risk Management – Creating risk management culture	Risk Management – Minimising uncertainty
Spearman's rho	Risk Management – Supply chain visibility	Correlation Coefficient	1.000	.295	.397
		Sig. (2-tailed)	.	.378	.227
		N	11	11	11
	Risk Management – Creating risk management culture	Correlation Coefficient	.295	1.000	.487
		Sig. (2-tailed)	.378	.	.128
		N	11	11	11
	Risk Management – Minimising uncertainty	Correlation Coefficient	.397	.487	1.000
		Sig. (2-tailed)	.227	.128	.
		N	11	11	11

Correlations

			Sourcing and Network design – Supply chain structure	Sourcing and Network design – Market sensitiveness	Sourcing and Network design – Technological capability
Spearman's rho	Sourcing and Network design – Supply chain structure	Correlation Coefficient	1.000	.384	.101
		Sig. (2-tailed)	.	.243	.767
		N	11	11	11
	Sourcing and Network design – Market sensitiveness	Correlation Coefficient	.384	1.000	.637*
		Sig. (2-tailed)	.243	.	.035
		N	11	11	11
	Sourcing and Network design – Technological capability	Correlation Coefficient	.101	.637*	1.000
		Sig. (2-tailed)	.767	.035	.
		N	11	11	11

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

			Supplier Relationship Management – Collaboration among players	Supplier Relationship Management – Trust among players	Supplier Relationship Management – Risk and revenue sharing	Supplier Relationship Management – Information sharing among players
Spearman's rho	Supplier Relationship Management – Collaboration among players	Correlation Coefficient	1.000	.790**	.498	.797**
		Sig. (2-tailed)	.	.004	.119	.003
		N	11	11	11	11
	Supplier Relationship Management – Trust among players	Correlation Coefficient	.790**	1.000	.653*	.758**
		Sig. (2-tailed)	.004	.	.029	.007
		N	11	11	11	11
	Supplier Relationship Management – Risk and revenue sharing	Correlation Coefficient	.498	.653*	1.000	.452
		Sig. (2-tailed)	.119	.029	.	.163
		N	11	11	11	11
	Supplier Relationship Management – Information sharing among players	Correlation Coefficient	.797**	.758**	.452	1.000
		Sig. (2-tailed)	.003	.007	.163	.
		N	11	11	11	11

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).