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# Procurement Action Plans in Semiconductor Shortage

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One year after completing my bachelor of engineering in plastics technology, a work opportunity brought me to complete financial management part of vocational qualification in business administration. Professional courses were always taken alongside full-time employment to offer some sparks of challenge and to prepare commitment for the grand plan to pursue academic growth. Professional and specialisation study modules at Metropolia's industrial management master's degree really refined and modernized the required competence as they enable self-steering, yet full of professional insights.

My gratitude is extended towards Aventura Oy for the thesis project collaboration. Special mention goes to the Senior Partner, Timo Markkula, M.Sc. for the collaboration in three significant stages of the study; Aventura's CEO, Jan Sjöblom for the feedback and validation received; and co-workers for the flexibility allowed to conduct the studies. Special thanks go to all the suppliers who have participated in the questionnaire with all the insightful responses.

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Special thanks to Max and Adrian for the motivation boost and for being very well-behaved during Mommy's studies.

This project was truly a showcase of focus, discipline and commitment which bears fruit in the end. The author is finally no longer a Jack of all trades, master of none.

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<p>The objective of the study is to propose actions to improve Aventra's contact chip procurement process due to the globally identified semiconductor shortage. The impact is seen primarily in procurement, production, and sales department. Under perfect circumstances, a JIT inventory system would be the desired management strategy. Consequentially, the supply shortage has made it difficult to achieve a high level of customer satisfaction due to longer production time. The entire smartcard industry is suffering due to this backlash.</p> <p>Applied action research was selected as the research design combined with qualitative methods by means of method triangulation. The thesis study includes four stages. The first stage is the current state analysis identifying advantages and challenges of the procurement process. The second stage is the conceptual framework, featuring literature review from available best practices to seek improvement suggestions to the challenges encountered in the first stage. The third stage is the co-created initial action plan proposal towards the stakeholder by utilizing findings from the previous stages. The fourth as the final stage is the validation of the initially proposed procurement action plan by gathering feedback from the stakeholders. Additionally, recommendation for potential implementation plan was also documented.</p> <p>Procurement process advantages and challenges were identified through procurement process map analysis. The findings and action plan proposals were categorized into three subgroups. The three challenge categories were forecast analysis, supplier coordination, and stock and lead time. The chosen academic literature focus on solving the supplier coordination category in practical aspects.</p> <p>The outcome of this thesis is a list of proposed partial improvement plan including strategical guidelines and action steps which can be implemented to smooth out the procurement process of semiconductor products. All proposed elements are targeted to provide Aventra Oy supplier coordination solutions to cope with the prolonged global semiconductor shortage.</p>	
Keywords	PKI smart card, Semiconductor shortage, Procurement process, Supplier coordination, Action plan, Moscow prioritization

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## Acronyms

ABC	Activity based costing
ACMS®	Aventra Oy's Active Content Management System (also known as ActiveCMS®)
APM®	Aventra Oy's Active Process Manager
ATO	Assemble-to-order
B2B	Business-to-business
BPR	Business process re-engineering
CE	Concurrent engineering
CEO	Chief executive officer
COVID	Coronavirus disease
CR80	Standard size of an ID card (8,56 cm x 5,398 cm)
CRM	Customer relationship management
DESFire	Data Encryption Standard Fast Innovative Reliable and Secure
DPI	Dots per inch
DSLR	Digital single-lens reflex camera
EOL	End-of-life product
ETD	Estimated time of delivery
ETO	Engineer-to-Order
FGs	Focus groups
IDI	In-depth individual
JIT	Just-in-time
KSRM	Key supplier relationship management
LSP	Logistics service performance
MCS	Management control systems
MIFARE	Mikron FARE Collection System
MOQ	Minimum order quantity
MNC	Multinational corporations
MTO	Make-to-order
MTS	Make-to-stock
NXP	Next Experience (formerly Philips Semiconductors)
OBE	Organisational buying effectiveness
OECD	The organization for economic cooperation and development



OC	Order confirmation
OEM	Original equipment manufacturer
PDM	Product data management
PDP	Product delivery process
PIV	Personal identity verification
PKI	Public key infrastructure
PM	Process management
PVC	Polyvinyl chloride
RFID	Radio-frequency identification
SCM	Supply chain management
SCO	Supply chain orientation
SLA	Service-level agreement
TQM	Total quality management
UV	Ultraviolet, form of electromagnetic radiation
VAR	Value added reseller

# 1 Introduction

Beside the shortage on raw materials such as aluminium, copper and silicon, hundreds of industries have felt the impact of the global chip shortage starting from the pandemic outbreak. Throughout the first wave, countries implemented various lock-down measures, work from home orders and business closures. Those measures have made a significant impact on the chip manufacturing industry. As most industries are implementing remote working to combat the spread of coronavirus, demand in electronic products have seen a major spike.

Due to this elevated demand, prices of chips have increased significantly after the pandemic, which results in increased sales revenue for NXP Semiconductor. Supply times of PKI smart card modules are always relatively long regardless of the COVID-pandemic. Large quantity must be purchased at a time, to serve our production for a longer period.

This thesis is written in collaboration with Aventra Oy's team who could benefit from the findings. This could also ultimately be used as an industrial guideline for other PKI cards' manufacturers also dealing with the global chip shortage.

## 1.1 Business Context of Aventra Oy

The thesis work is relevant to Aventra Oy's supply chain, especially concerning chip products. Aventra Oy is a Finnish company which was founded in 2004 and operates mainly in security software development industry. The company is a single entity, and not tied to any group company. The company's owners still work within the company as solution developers.

There is an ease of access to customers and partner companies ever since the entire operation has been moved closer to centre of Helsinki in summer 2022. The entire operation includes identity and access management, software development and consulting, card printers, embedded contact, RFID, library, and membership cards as well as key fobs personalization.

The customers are globally spread across the continents. Aventura Oy has active salesforce, production, support and service and software developing teams located in Helsinki and the company joined HID global partner program in 2022.

In addition to salesforce, in-house developed and run Webshop has been utilized to boost sales figures. An in-house developed web-based card order system with a DSLR interface has also been employed, which enables a potential customer to capture a self-picture, taken from their personal computer's webcam or built-in laptop camera. The customer can then place more details such as texts and / or other logos or figures card to Aventura's VisualPerso™ card manager system. After the customer is satisfied with the end result, ActivePerso Manager™ can then process the order further and customers will likely receive their self-personalized cards within 2 – 5 business days, depending on the method of dispatch selected.

All the licenses from card personalization software mentioned above are able to be leased, along with 600 or 300 dpi printers to further enable corporate customers or those working in security instances to maintain their cards' production on their premises, which in turns lowers the risk of delivery error.

Companies have purchased or leased card printing machines and spare devices from Aventura Oy. The company employs seasoned card printing experts with more than 30 years of experience from the field. Aventura's service and support team are always on the ready to help with any issue that the customers might face. After joining the HID global partner programme, Aventura Oy has an easier time finding solutions to any technical issue the support and system team might be facing.

Figure 1 depicts the number of individuals employed in each department or the roles they undertake within the organization, generated from Aventura Oy's personnel handbook v.21. Managers are marked in orange and each department has an appointed person responsible to maintain the performance

and output of their fellow teammates. The organization hierarchy has been tried to be kept as flat as possible, and every single member has individual key roles, tasks, and responsibilities to attend to.

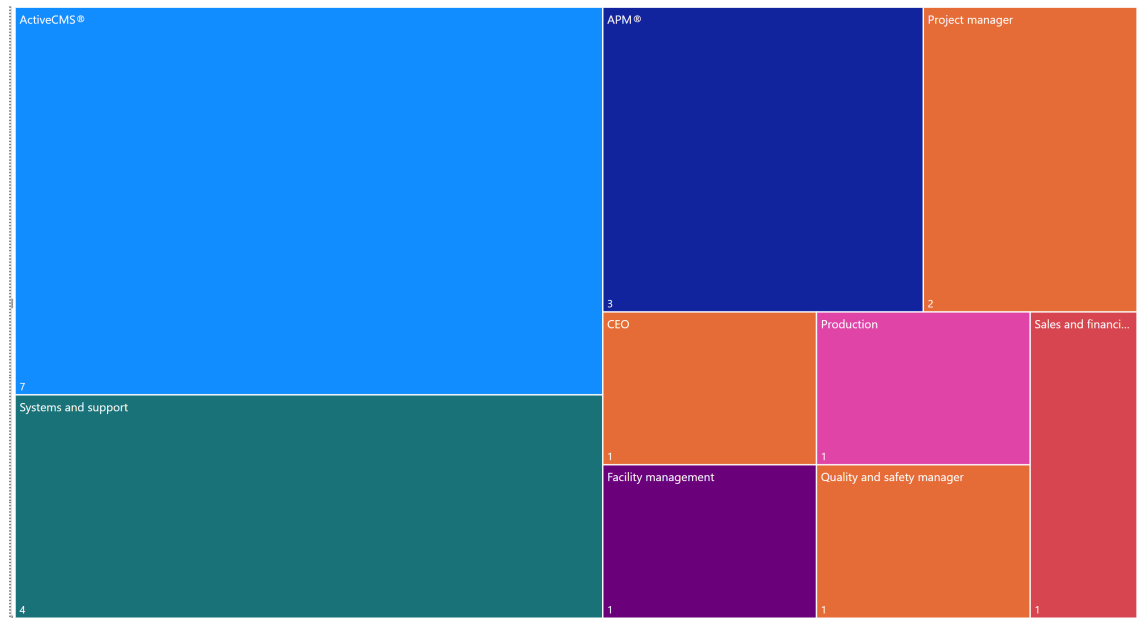


Figure 1 - Number of individuals per department or roles modified from Aventura Oy's employees handbook (Aventura Oy, 2022)

Aventura Oy has shifted its focus solely from the former card printing industry to identification security software provider. Aventura Oy has accomplished quite many remarkable public procurement announcements. Due to its competitive prices and ability to deliver according to the agreed SLA, many customers have continued to deploy Aventura's systems for years, even after the minimum contract period has already been completed.

The organization has oftentimes considered how their typically implemented lean inventory principal system can be applied during semiconductor shortage.

## 1.2 Business Challenge, Objective and Expected Outcome

As the title implies, the business challenge that prompted the author to write this master's thesis work is the globally identified problem of a chip shortage and how it impacts PKI card manufacturers.

The impact of the problem is seen primarily in procurement, production, and sales department. But it also secondarily impacts the entire operation, as development projects have a potential gravitation to revolve around the availability of available material and technology used.

By spring 2021, many Far Eastern chip OEMS implied that the chip shortage problem was expected to normalize by summer 2022. In hindsight, that prophecy was proven to be rather short-sighted. One supplier based in the Far East had informed that a mobile phone manufacturer was bulk purchasing and emptying supplies of NXP's VARs. This notion resulted in staggering inflation in embedded chip products. Many of these Far Eastern suppliers have inquired an estimated forecast of annual purchase volume in advance, as they are likely to prioritize customers with binding long-term contracts which helps them plan manufacturing capacity.

As reported in 2022, there will not be enough capacity in the market to meet demand and fill backlog until the end of the first quarter of year 2022. The automotive industry has been hit particularly hardest. Some car manufacturers even predict that the normalization would take some time in 2025 and the impact might still be felt within the next two decades.

Under perfect circumstances, a JIT inventory system would be the desired management strategy. Consequentially, the supply shortage has made it generally impossible to achieve a high level of customer satisfaction due to longer production time. The entire smartcard industry is suffering due to this backlash.

Key Supplier 2 based in northern Germany reported in late 2021 that lead time cannot be assured anymore due to uncertainty from module suppliers caused by worldwide chip shortage. NXP's JCOP3 J2H145 Java Card 3.0.4, which supposedly will still be available in the long run has seen some proposed new strings of key identifiers. One major impact of this state of uncertainty is that there is a longer waiting period for testable chip embedded card to be retrieved, hence initial applet installation tests will be harder to conduct on modules which have not been received before.

The issues are also as prevalent in RFID cards such as the newer DESFire EV3 and EV2 modules. In 2020, end-of-life notifications were announced for DESFire EV1 modules. Due to the shortage, it becomes increasingly difficult to obtain EV2 chips. Even then, EV1 has been lately sold at a skyrocketed value and the price has doubled compared to the previous year. Lower capacitance of 17pF has been more commonly offered instead of 70pF. Upon offer, there is rarely any assurance that the chips are actually reserved prior to OC.

The objective of this master's thesis work is to propose actions to improve Aventura's contact chip procurement process during global chip shortage.

The outcome of this thesis is a list of proposed partial improvement plan including strategical guidelines and action steps which could be used to smooth out the procurement process of semiconductor products.

### 1.3 Outline of the Thesis Report

The study includes current state analysis on market behaviour surrounding embedded chip card products. The study does not include other businesses impacted by the present global chip shortage such as automotive, computing, gaming, and entertainment industries.

The study includes 7 sections. Section 1 is an introduction to the study. Section 2 describes the project plan, data collection and assessment of the selected project plan. Section 3 contains current state analysis and recapitulates the

results. Section 4 investigates applicable literature to further support reaching the objective. Section 5 is an introduction of prototype procurement model solution to Aventura Oy based on objective of the study, section 3 and 4. Section 6 is the testing procedures done at Aventura Oy, which will generate any improvement recommendations. Section 7 is self-evaluation and concluding the master's thesis project (Collins, 2022).

## **2 Applied Research Plan**

Section 1 describes the business context, the challenge that the industry is facing, objective of the research and the expected outcome. This section explores the selected research approach and design with the data collection plan.

### **2.1 Qualitative Research Approach and Method Triangulation**

Applied action research was selected as the research design combined with qualitative methods by means of method triangulation. Qualitative research approach is best suited for this study because the specific phenomenon is considerably new. The desired outcome is to create a more in-depth view of the phenomenon and produce reasonable interpretations and applications from the new theories and hypotheses the study produces. In order to conduct further quantitative research which can be directly utilized in marketing research and forecasting, the theories and models have to first be constructed by using qualitative approach (Kananen, 2013, pp. 31-32).

Method triangulation uses multiple methods of data collection about the same phenomenon (Polit & Beck, 2012). Method triangulation is frequently used in qualitative research and may include interviews, observation, and field notes. According to Carter, et al. (2014, pp. 545-547), IDI (in-depth individual) interview is one of the most powerful tools for gaining an understanding of human beings and exploring topics in depth. Fontana & Frey (2000, pp. 645-672) adds that IDI interviews allow for spontaneity, flexibility, and

responsiveness to individuals; although conducting the interviews, transcribing the discourse, and analyzing field text require considerable time and effort (Carter, et al., 2014, pp. 545-547).

IDI interviews generate more ideas than moderated or unmoderated FGs (focus group interviews) (Fern, 1982). IDI focuses on finer details, whereas FGs identify potential issues (De Jong & Schellens, 1998, pp. 77-88). IDI interview participants stimulate discussion about various topics, even sensitive ones when compared to FG participants (Kaplowitz, 2000, pp. 419-431).

Unlike case research, action research tests the researchers' recommendations to eliminate the problem and measures to show the change in practice. Action research aims for a change through participation. The action research conductor is often a member of the research object (Kananen, 2013, pp. 40-45).

## 2.2 Applied Research Design

Stages of the action research is depicted in Figure 2. Action research is process-like by nature and goes through cycles which follows each other. Business operations are subjected to on-going development (Kananen, 2013, p. 44).

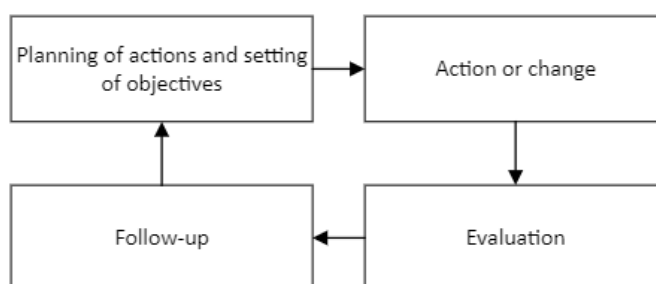


Figure 2 - Stages of action research (Kananen, 2013, p. 42)

As previously elaborated in 2.1, method triangulation is used to pinpoint the data collection points and to illustrate the workflow. Figure 3 depicts the research design of this study and further specifies its different stages such as



current state analysis to summarize the procurement process advantages and challenges, conceptual framework based on literature review, initial proposal and prototyping, and lastly to validate the feedback gained from the proposed procurement process model.

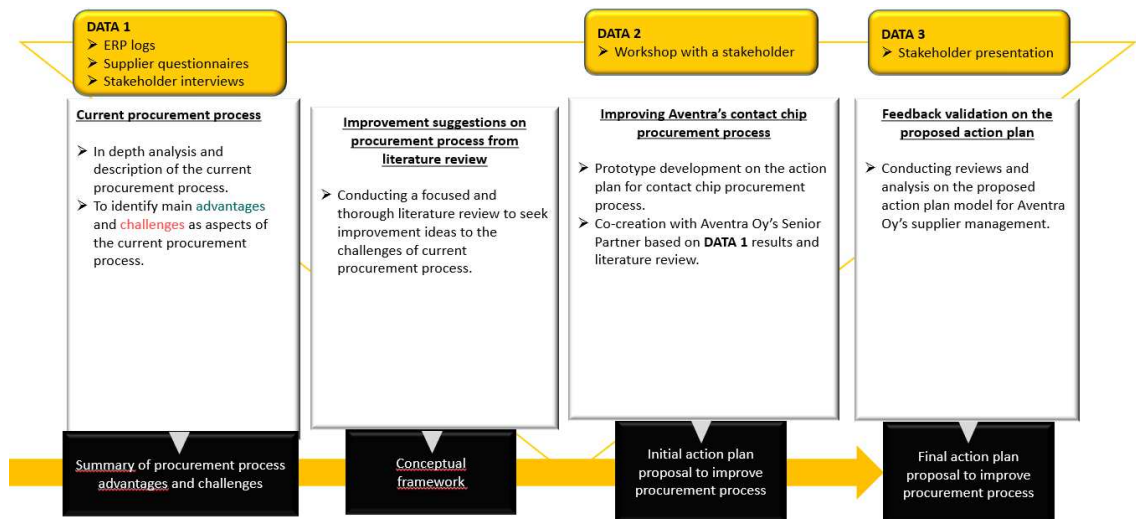


Figure 3 – Research design, modified from Gate 2 research design slide 7 (Rohweder, 2022)

As illustrated in Figure 3, the first stage of the thesis is the current state analysis of the current chip products' procurement process described in Section 3. The objective is to conduct an in-depth analysis and description of the current procurement process. Method triangulation was utilized to generate a broad data. Aventura's supply chain data and a set of questionnaires were sent to supplier companies with the most critically scarce chip modules. After gaining enough background theory, theme interviews were held to the Senior Partner of Aventura Oy and Management Role 1. The outcome of this stage is identified advantages and challenges as contributing aspects of the fundamental cornerstone to the analysis as the author goes further along the research study.

Section 3.2 features a procurement process map. According to Damelio, the functions of process mapping are as follows:

- To help the responsible individual to agree on the used terms and to develop common mental models on performed tasks.
- To make each team member comprehends their throughput sequence contribution in the company's principal processes.
- To provide visibility to the work architecture, including boundaries, components, features, and properties as a catalyst for enhancing, monitoring, and executing succeeding actions.
- To improve communication and comprehension within the entire team by emphasising focus.
- To document work-related knowledge. It may be a set of documents which collectively describe the current best practices. The documents are maintained and revised as a part of daily activities for the relevant process owner or value stream manager.
- To establish or to modify the enterprise-level workflow architecture, which provides context for process management and improvement. If a local modification should occur, the process map clarifies the effect on the company's primary workflow. Process map also visualizes the relationship of how one process is linked to another.

(Damelio, 2011, p. 32)

The second stage illustrated in Figure 3 is the conceptual framework, featuring literature review with an objective to seek improvement suggestions to the challenges of current procurement process gathered in Data 1. The author means to conduct a focused and thorough professional academic literature

review. The outcome of this stage is available best practices for the current procurement process.

The third stage illustrated in Figure 3 is the initial proposal towards Aventura's stakeholder. The objective of Stage 3 is to generate the second set of data consisting initial action plan proposal to improve the procurement process. Data 1 gathered from Stage 1 current state analysis and Stage 2 literature review will be utilized for this developmental stage. Data 2 is gathered through further stakeholder interviews and further meetings and discussions. The outcome is a co-created prototype of a partially improved contact chip procurement process.

The fourth stage illustrated in Figure 3 is the final proposal towards Aventura's stakeholders. The objective of Stage 4 is to validate the feedback gathered from the proposed procurement process. Data 3 is gathered through FGs briefings with the stakeholders and conducting tests and reviews on the proposed improvement model within Aventura Oy's ERP and supplier management systems embedded within. The outcome of Stage 4 is the compiled final action plan proposal to improve the procurement process.

### 2.3 Data Collection Plan

In order to increase validity of research findings and narrow down the number of participants, triangulation and data collection is done through IDI interviews and followed by FGs. Data collection methods will be compared to study results from each method and how the data were integrated to the study results will then be described. This approach restricts the number of study participants to only those who can participate in both methods (Carter, et al., 2014, pp. 545-547). The complete data collection plan to this research study can be observed in Table 1.

Table 1 – Data collection plan

	Content	Methods	Informant	Schedule	Outcome
<b>DATA 1</b> Analysis of current procurement process	<ul style="list-style-type: none"> <li>➢ In depth analysis of current procurement process.</li> <li>➢ Identify main <b>advantages</b> and <b>challenges</b>.</li> </ul>	<ul style="list-style-type: none"> <li>➢ ERP logs (.csv)</li> <li>➢ Key suppliers' questionnaire results (MsForms)</li> <li>➢ Stakeholder IDI interviews (live)</li> </ul>	<ul style="list-style-type: none"> <li>➢ Aventura's Taloushallinto™ logs</li> <li>➢ 58 sales representatives from 46 chip product suppliers.</li> <li>➢ Senior partner</li> <li>➢ Management Role 1</li> </ul>	<ul style="list-style-type: none"> <li>➢ 20.11.2022</li> <li>➢ 20.01.2023 - 03.02.2023</li> <li>➢ 17.01.2023</li> <li>➢ 24.01.2023</li> </ul>	Summary of procurement process' advantages and challenges
<b>DATA 2</b> Improving current procurement process through action plans	<ul style="list-style-type: none"> <li>➢ Improving challenges gathered in <b>DATA 1</b>.</li> <li>➢ Embedding key advantages identified in <b>DATA 1</b>.</li> </ul>	<ul style="list-style-type: none"> <li>➢ Workshop with stakeholder / ERP system developer (live)</li> </ul>	<ul style="list-style-type: none"> <li>➢ Senior partner</li> </ul>	14.03.2023	Initial action plan proposals to partially improve procurement process
<b>DATA 3</b> Feedback validation on the proposed action plans	<ul style="list-style-type: none"> <li>➢ Gathering feedback from stakeholders based on the initial proposal.</li> </ul>	<ul style="list-style-type: none"> <li>FGs interview and workshop with stakeholders (live).</li> </ul>	<ul style="list-style-type: none"> <li>➢ CEO</li> <li>➢ Senior partner</li> </ul>	23.03.2023	Final proposal on a partially improved procurement process action plan

As described in Table 1, Data 1 was gathered through structured open questions with the author's vaguely pre-existing views and some theory based on the semiconductor shortage phenomenon researched. As a thesis study researcher, the author's role in the interview was as a non-opinionated, probing observant. Therefore, leading questions and themes were avoided to ensure the ethical standard of the research.

In addition to assisting Data 1 gathering process, the function of the initial stakeholder interview was also to formally inform Aventura Oy that research project has been officially commenced. To gain an in-depth understanding of the phenomenon, theme interviews were held with Aventura Oy's senior partner, Timo Markkula MSc., who worked as the CEO of Aventura Oy prior to his retirement and the co-founder of the company. Decades of seasoned expertise in the security system industry means that his insights are held precious. To these days, he is still appointed as the person who holds introduction day to PKI and Aventura's history to new recruits. The IDI interview was initially intended to be 15 – 30 minutes long but it was extended to 2 hours due to the vast content and the currently critical status at hand.

IDI interview to the Management Role 1 was held in a separate occasion. Due to the always fully scheduled January, the CEO was not yet considered to be a

part of IDI interviews and rather as a part of FGs interviews at Data 3 developmental process.

Field note was used as a method of recording the stakeholder interviews. The anecdotes were jotted down into a blank field note form, which was later documented and delivered to interview respondents in order for them to review and confirm the accuracy of the anecdotes, before they can be utilized as citations in the author's thesis work.

To supplement current state Data 1 and as previously described in Section 2.2, lead time data from each chip modules suffering from the worst impact of global semiconductor shortage was retrieved from Aventura's ERP logs, further visualizations were generated from these data. The lead time visualization was utilized as the final project submission from Business Data Analytics and Visualization course held by the head of industrial management program, Dr. Sami Sainio.

Additionally, as a supplementary Data 1 collection and as previously stated in Section 2.2, a set of online Microsoft Forms questionnaires were sent to 46 supplier companies, comprising 58 sales representatives with the most critically scarce chip modules. The questionnaires will answer suppliers' manufacturing methods which contributes to the lead-time, other lead-time questions related to the global chip shortage, how the pandemic has impacted their businesses and how the suppliers have mitigated the risks caused by supply chain disruption.

As described in Table 1, Data 2 of initial proposal was gathered through further IDI workshop with the Senior Partner. The workshop took 2,5 hours and the result is gathered in raw field notes of Appendix 5.

Data 3 of final proposal was then gathered through feedback from stakeholders including the CEO and the Senior Partner to validate the findings on the initially proposed procurement process improvement. Unlike the previous interview methods, Data 3 will feature FGs presentation and validation inquiry so

everyone's professional opinions will be taken into account and enabled for development ideas. The presentation took an hour and the results gathered is featured in raw field notes of Appendix 6.

This thesis study also consists supplementary materials gathered from Aventura's internal documents. The functions of each featured internal documents are explained in Table 2.

Table 2 – Internal documents as a guideline for this thesis study

#	Name of document	Number of pages	Description
1	Employees handbook v21 (FIN: <i>Henkilöstökäsikirja</i> )	28	Code of conduct based on fundamental working rules and guidance
2	Quality handbook v1.6 (FIN: <i>Laatukäsikirja</i> )	12	quality control of products and services applied practices to ensure that they meet customer requirements.
2	ERP systems instructions (FIN: <i>Ohjeita taloushallintoon</i> )	10	Software overview and user manuals
3	Offer template (FIN: <i>Tarjouspohja 2020_EN</i> )	5	Sales template for company introduction, product or service specification and terms.

4	Inventory flow data acquired from the ERP logs	-	Lead time analysis on the current procurement flow
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Each document listed in Table 2 has been utilized in the thesis study as follows:

- 1) Employees handbook v21 (FIN: *Henkilöstökäsikirja*) contains an organizational chart, which was re-illustrated in Figure 1 to depict the number of individuals per department or roles within Aventura Oy.
- 2) ERP systems instructions has been utilized in providing introductory elements to Section 3.1, the overview of the current state analysis.
- 3) The offer template was utilized to complement the author's views on what Aventura Oy sells, and it provides in-depth business context of Aventura Oy found in Section 1.1, as the company might not be entirely familiar to the readers before due to the comparatively small size.
- 4) Inventory flow data acquired from the ERP logs largely supports lead time analysis on the current procurement flow.

## 2.4 Data Analysis and Research Plan Summary

Data 1 comprising ERP logs on lead time, key suppliers' questionnaire results and stakeholder IDI interviews were analysed through the produced visualizations provided by the collected results. The analyzation from the collected results is discussed together with the ERP stakeholder to create initial procurement process improvements to create Data 2. Data 2 will be assessed further, and the proposal is open for validation with the entire stakeholders through FGs interview and workshop with stakeholders to co-develop Data 3, which is the final action plan proposed to improve the procurement process.

The following section presents the findings compiled in Data 1 based on current state analysis of Aventura Oy's procurement process.

### **3 Analysis Of Aventura's Current Procurement Process**

This section analyses the current state of the current procurement process and examines the results according to their respective advantages and challenges. This section starts with a brief overview of the current procurement process and then proceeds onto describing, illustrating, and dissecting its key advantages and challenges.

This section features a procurement process map. The functions of process mapping have been described in Section 2.2.

#### **3.1 Overview of the Current State Analysis Stage**

As described in Section 1.2, the objective of this master's thesis work is to propose actions to improve Aventura's contact chip procurement process during global chip shortage. The CSA stage was carried out by organizing IDI interview sessions to different stakeholders involved in Aventura's supply chain process and its development as well as supply chain themed questionnaires to the suppliers.

In addition to assisting process data's gathering process, the function of the initial stakeholder interview was also to formally inform Aventura Oy that research project has been officially commenced. To gain an in-depth understanding of the phenomenon, theme interviews were held with Aventura Oy's senior partner, Timo Markkula, MSc., who used to be the CEO of Aventura Oy prior to his retirement in October 2021 and the co-founder of the company. The respondent was selected because of his role in Aventura's ERP system development. Decades of seasoned expertise in the security system industry means that his insights are held precious. To these days, he is still appointed as the person who holds introduction day to PKI and Aventura's history to new recruits. The IDI interview was initially intended to be 15 – 30 minutes long but it



was extended to 2 hours due to the vast content and the currently critical status at hand.

Procurement process map for contact chip products shown in Figure 24 of Appendix 1 was first predesigned according to the author's analysis. The proposed map had to be drawn in advance and was subjected to analysis and modifications in the interview process. This approach shortens the time of the interview due to limited available time in January. Figure 24 was analysed together with the Senior Partner and the redrawing procedure can be seen in the field notes of Appendix 1.

The third question directed towards the Senior Partner was to gather criteria why some long-term key suppliers of chip products were selected. The fourth question was to gather reasons why NXP's JCOP chips were the most suitable solution for embedding MyEID cards instead of options from other OEMs, while presenting alternatives to alternative contact chip cards. The fifth question pondered the need to provide a polished calculation model based on existing literature analysis in conceptual framework stage instead of the current 2-months average consumption level manual input to enable low stock level alert. The last question's purpose was to gather advantages and challenges of the current procurement process together with the Senior Partner. The interview questions and field notes can be viewed in further detail in Appendix 1.

The second interview was held with Management Role 1 who works directly with the affected chips impacted by the global semiconductor shortage. His views on the advantages and challenges of the current procurement process were considered fruitful to the author's research process.

Due to limited time available to conduct the interview within Aventura Oy's production site but still in order to provoke critical answers, the author had carefully curated the open-ended questions by using statements, in which the Management Role 1 can strongly agree or disagree with by using a scale from 1 – 5. The questions ranged from the global chip shortage's effect on the

production, lead time, tighter deadlines forcing simultaneous operation on multiple machines, repeated spontaneous agile manufacturing improvisation methods, customer satisfaction level, proposed procurement model based on best practices, proposed delivery agreement model in accordance with Aventura's quality handbook and suggested procurement status scrum at the beginning of each business week. The interview questions and field notes can be found in Appendix 2.

Lead time data from each chip products suffering from the worst impact of global semiconductor shortage was retrieved from Aventura's ERP logs, and further visualizations were generated from these data. A set of questionnaires was sent to 46 supplier companies, comprising 58 sales representatives with the most critically scarce chip modules.

The questions ranged from the suppliers' manufacturing workflows, revenue growth according to their last financial statement, NXP® Semiconductors smart cards supplied, their views on post-pandemic delivery lead-time impact for each supplied chip product, average delivery time before 2020 and in spring 2023, their forecast on when the supply chain disruption is going to subside for each chip product and their methods to mitigate chip shortage issues. The questionnaire and compiled answers are found in Appendix 3.

The current procurement process is mapped in Section 3.2 and the lead time data contributing to this study is illustrated in Section 3.3.

## 3.2 Procurement Process Map

The procurement process map was created with the help of Microsoft Visio. As previously mentioned in Section 1.2, the impact of the supply chain issue caused by chip shortage is mostly apparent in procurement, production, and sales department. The proposed procurement process map shown in Figure 24 of Appendix 1 was enhanced as suggested by the Senior Partner to provide readability and clarity of the logic by expanding the right-hand area. This enhanced version of procurement process map is shown in Figure 4.

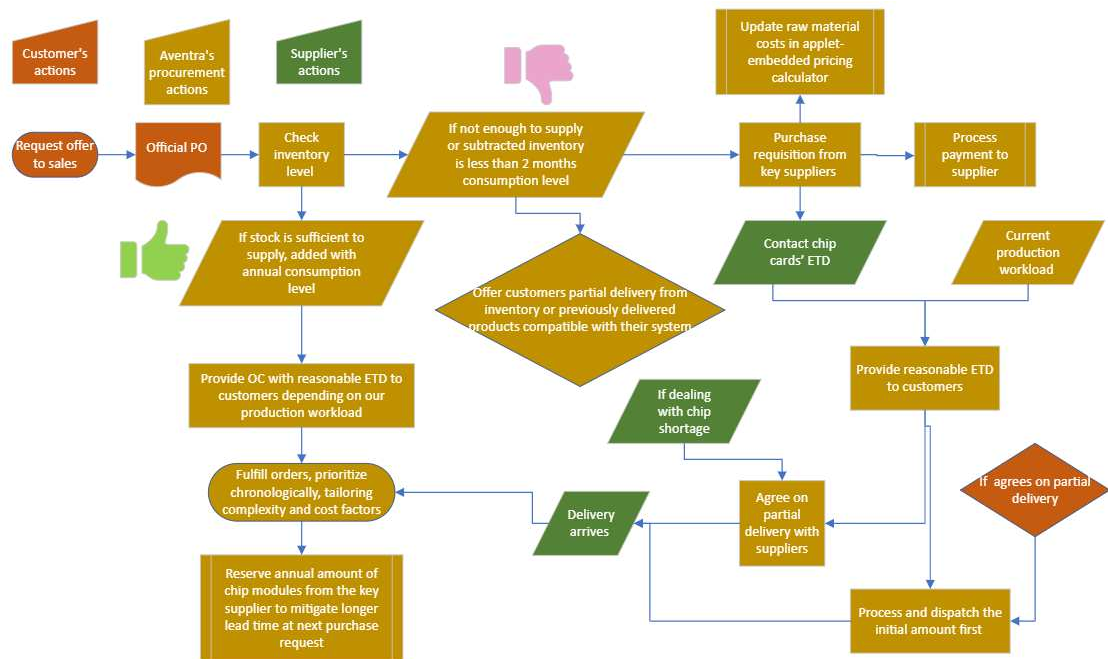


Figure 4 – Procurement process map

Naturally all procurement processes start with the customer's offer request to the sales department and official PO when the sales offer has been accepted by the customer. Aventura then proceeds to check the inventory level. The next action depends on the following stock level status:

If stock is sufficient to fully supply the entire order, added with 2-months average consumption level, then provide an OC with reasonable ETD to the customers depending on the current production workload. The production will commence order fulfilment by prioritizing chronologically depending on the PO receipt date, tailoring complexity and cost determining factors.

In case the stock is not sufficient to supply the entire order, or the subtracted inventory level is less than a 2-months level of consumption, then the following supply chain actions should be taken:

Sales department should offer customers a partial delivery from the existing stock or existing previously delivered products deemed compatible with their system.

Procurement should issue purchase requisition from a key supplier. From the offer received, procurement should then update the raw material costs in applet-embedded pricing calculator. If the supplier issues a proforma invoice, then account payables process the payment to the supplier.

Sales department provides reasonable ETD to customers, taking into account the contact chip cards' ETD issued by the supplier and the current production workload.

In case the provided ETD is deemed too long by the customer, and if the customer agrees on partial delivery, Aventra's production processes and dispatch the initial amount from stock first before the delivery from supplier arrives.

In case the supplier is also dealing with chip shortage issues, then agree on partial delivery with the supplier while informing customers with the possible delay and ETD.

When the order arrives, the production will commence order fulfilment by prioritizing chronologically depending on the PO receipt date, tailoring complexity and cost determining factors.

After order fulfilment, procurement subprocess proceeds to check inventory level at the next purchase request, and in case it has fallen below 2-months average consumption level, then procurement will proceed to reserve the annual amount of chip modules from the key supplier to mitigate longer lead time.

Upon reviewing the proposed procurement process map, the Senior Partner expressed the following:

*It is worth investing time in developing the procurement process map.*

The respondent has an idea on developing production time slot feature within the ERP system, which informs production on the critical PO can be developed upon reaching the right side of the flow chart, on the process of providing a reasonable ETD to the customer. The time slot is based chronological PO inflow, first come first served. Time slot feature’s objective is to optimize resources, as the ideal case scenario is if the production line is always working more than 90% of its capacity.

### 3.3 Current Lead-time Data

Procurement data from Aventura Oy’s ERP system was employed to generate Figure 5 showing the lead time for contact chip cards related to order quantity. The earliest data was retrieved from 2019 and the latest is at the end of Q3 2022 to illustrate the lead time situation prior to the pandemic compared to the current state.

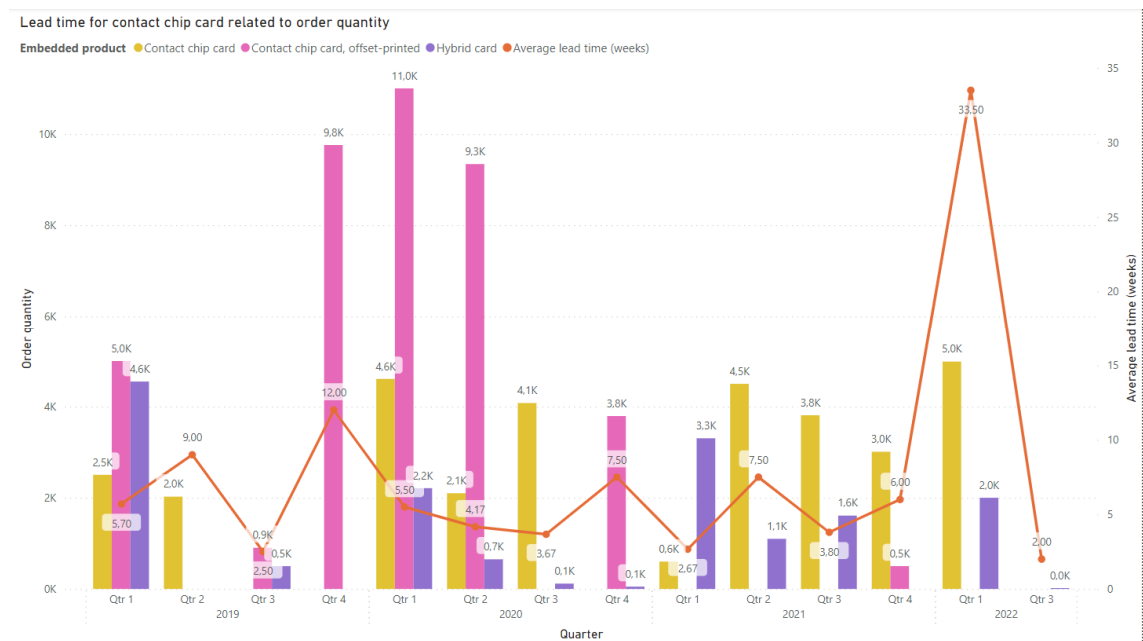


Figure 5 – Lead time for contact chip cards related to order quantity.

The columns mark the total ordered volume of each chip card product suffering the worst impact of global chip shortage. The yellow columns mark contact chip card, pink columns mark offset-printed contact chip card and purple columns

mark hybrid cards (dual interface cards also included). Orange line marks the average lead time from the time the PO has been issued to the supplier up to the complete order fulfilment date.

As observed in Figure 5, the average lead time has escalated significantly, and the situation does not seem to ease in Q1 2023 for orders that were made in Q4 2022. Order completion becomes increasingly difficult to fulfil by suppliers at a reasonable time frame and CRM skills have been put to test. The data retrieval methods for Figure 5 have been elaborated in Appendix 4.

### 3.4 Advantages of the Current Procurement Process

The main advantages of the current procurement process were identified through live IDI interviews, supplier questionnaire and ERP logs.

The discovered key advantages as Data 1 have been embedded in the procurement process map shown in Figure 6.

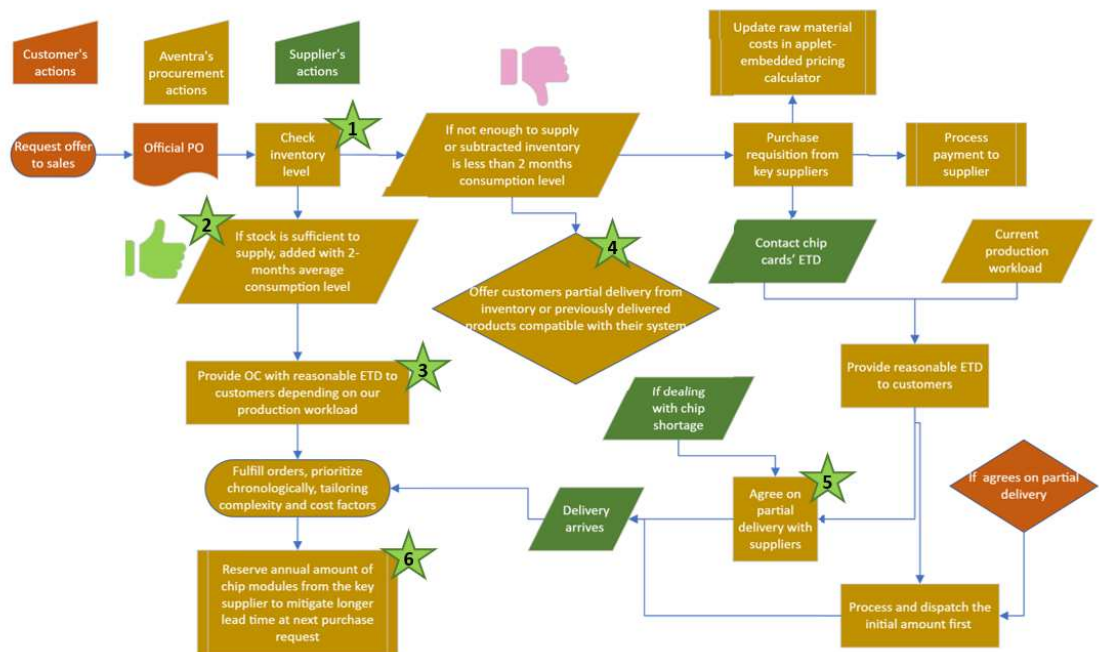


Figure 6 – Key advantages embedded in procurement process map.

The advantages shown in Figure 6 have been arranged according to the order of appearance in the procurement process flow. The advantages and their sources have been further dissected in Table 3.

Table 3 – Identified key advantages.

#	Advantages	Sources	Categorized and described in Section
1	Manageable with a smaller storage space	IDI interview with the Senior Partner	3.4.1
2	Improve cash flow, as cash is not tied up in inventory		3.4.1
3	ERP system is developed in house. New functional features are implemented fast.	ERP systems instructions (FIN: <i>Ohjeita taloushallintoon</i> )	3.4.2
4	Optimally as many inventory products as possible are still on-demand	IDI interview with the Senior Partner	3.4.1
5	It enables direct delivery from stock as often as possible due to close cooperation with reliable partners.		3.4.3

6	ERP's production status registers how many applets have been embedded in each order stage.	Observed during the early training period of 2020.	3.4.2
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From the key advantage identified in Table 3, the author has decided to pick the first, the third and the fifth as the focused advantages which impact the procurement process covered by this thesis study. The enhanced procurement process model which combines these three elements would be utilized as a potential solution to Aventura Oy.

#### 3.4.1 Manageable with a Smaller Storage Space

The first, second and fourth advantages mentioned in



Table 1 are all linked to smaller storage space manageability. When the storage space is optimized, then the second advantage of cash flow improvement as cash is not tied up in inventory, hence lowering the risk of obsolete asset which cuts into the profit margin.

The optimized model also means that as many inventory products as possible are still on-demand. As observed in Appendix 2, Management Role 1 agrees that repeated spontaneous agile manufacturing improvisation methods such as backwards product replacement has been conducted to respond quickly to customer needs and market changes while still controlling the costs and quality (Martin & Towill, 2001, pp. 236-237)

Figure 7 depicts the amount of contact and hybrid chip cards each year from 2019 – 2022 Q3. Year 2020 saw a mass purchase amount of offset-printed dual interface cards. The cards were mass purchased due to a contract and dispatched to several locations around Finland in 2020 and 2021. The contract for that personalized dual interface cards came to a halt, thus a slight decline can be observed in the purchase amount in Figure 7.

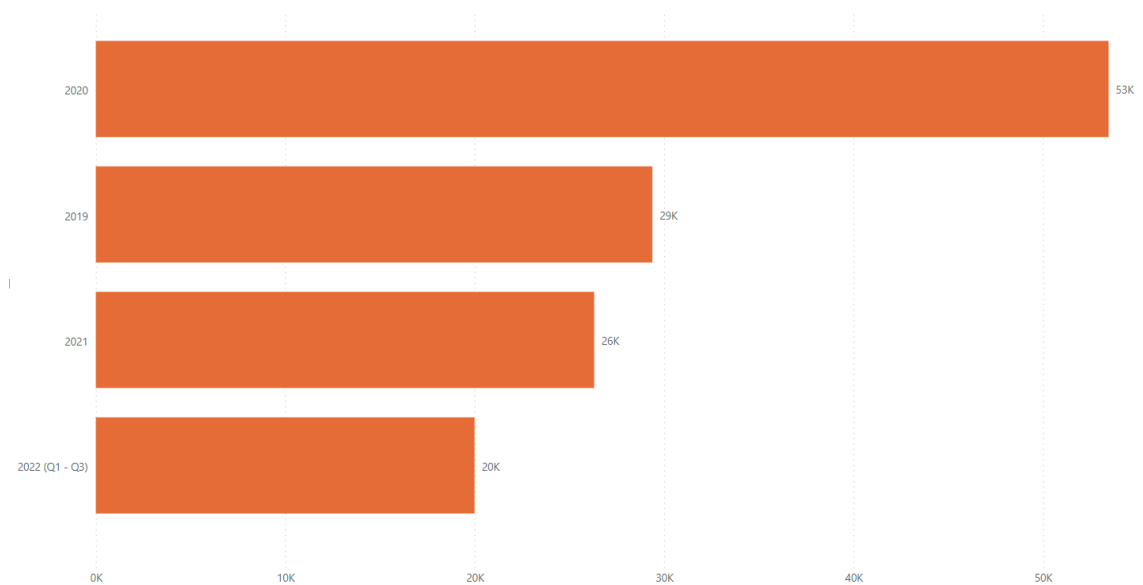


Figure 7 – Total purchase of contact and hybrid chip cards each year from 2019 – 2022 Q3

Spring of 2023 sees another high spike of purchase amount of contact and hybrid cards. Since the purchase amount has not yet been fully delivered, the lead time cannot be included in the graph as to not assume a forecast.

Another contributing factor to a smaller storage space is naturally the physical size of a standard CR80 PVC card. The entire purchase quantity of 2020 weighs around 278 kg, and the entire 106 boxes could easily fit in Aventura's storage rooms in Helsinki.

### 3.4.2 In-house Developed ERP System

The multifunctional *taloushallinto* software seen in Figure 8 runs on Microsoft Windows OS and logs Aventura's sales and purchase orders, its related deliveries, and invoices. The ERP system manages sales ledger, contract invoicing, inventory management, and produces various reports for the company and accounting needs (Aventura Oy). The main view of Aventura's *taloushallinto* software after the splash screen updates can be viewed in Figure 8.

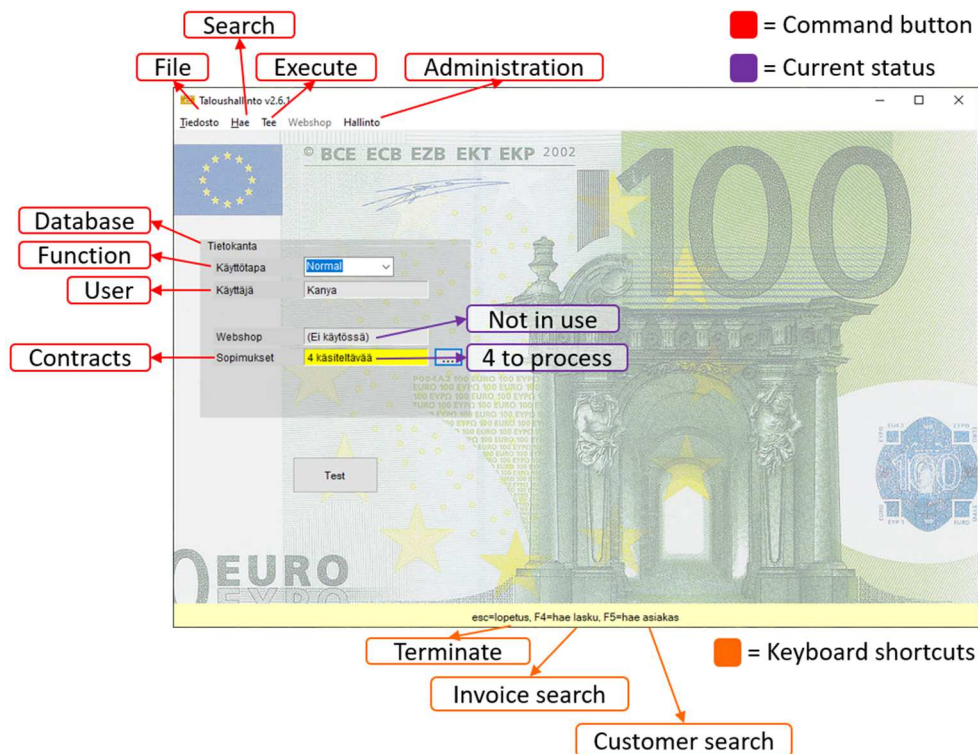


Figure 8 – Main view of Aventura's *taloushallinto* software translated to English.

Unlike any other ERP system that the author has had any professional experience with, *taloushallinto* is capable to run all the mentioned actions under one wing, instead of available with separated software or plug-ins like some commercially available counterparts. According to the senior partner, *taloushallinto* was initially designed to assist chip card production work. Currently no other existing PDM software is able to run and manage chip embedding production work that is connected with Aventura's accounting system.

The advantage of having an in-house developed ERP system is that new functional features are implemented quickly without a middle-person consultant or software sales agent. Whichever development recommendation may be communicated and registered directly into *taloushallinto*'s own Teams to-do queue, which will be reviewed and implemented if deemed important.

While working on this thesis study, one of the author's improvement suggestions was made into a change within the ERP system. Before the improvement suggestion mentioned, while prompted, the system used to generate report based on low stock level that has been set manually by the author. Upon the improvement suggestion, the Senior Partner altered the system to subtract the amount of product that has been ordered from the existing stock level, in order for that certain low inventory product to appear in the generated report.

The sixth identified key advantage in Table 3 mentions ERP's production status registers how many applets have been embedded in each order stage. From each order, the amount of chip cards with embedded applet and which plug-ins can be tracked as seen in Figure 9.

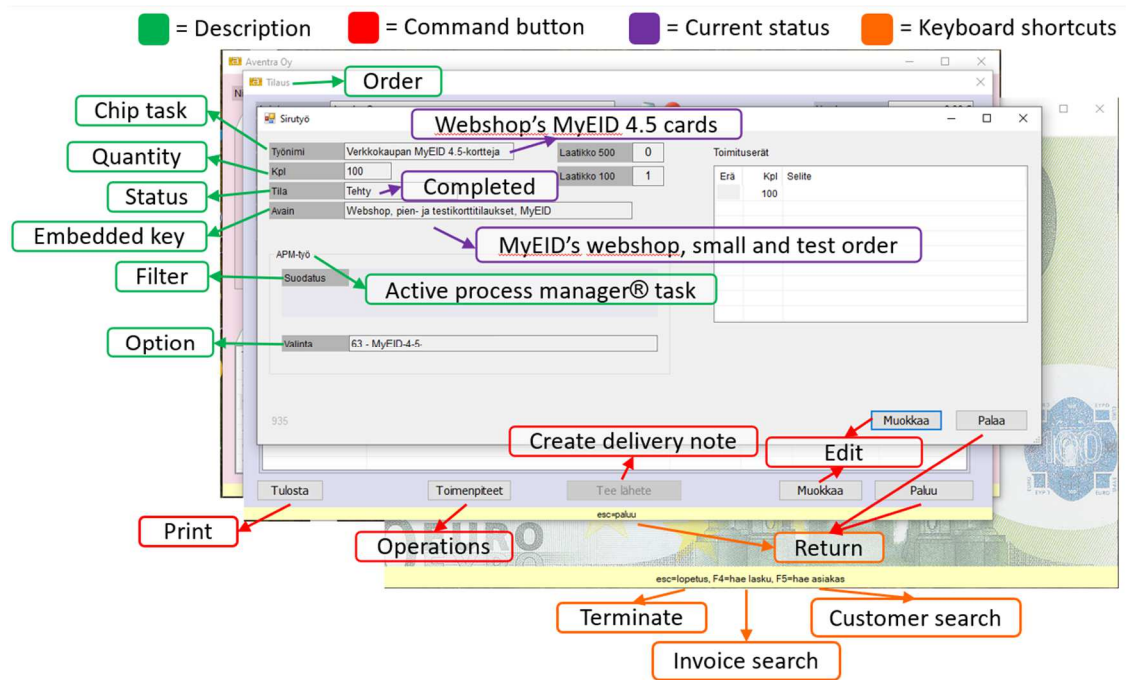


Figure 9 – Embedded applet log on each order translated to English

To protect the customer and order confidentiality, the order number, delivery batch number, plug-in options and applet version have been censored in Figure 9.

### 3.4.3 Close Cooperation with Reliable Partners

Referring to the results of IDI interview with the Senior Partner found in Appendix 1, one of the key advantages of current procurement process mentioned is:

*the ability to deliver directly from stock as often as possible due to close cooperation with reliable partners.*

Referring to subcontractors' printing quality described in quality handbook Section 5.4., the Senior Partner described the core criteria why long-term offset-printed card suppliers were selected:

*The price and printing quality. Flexible schedule has been noted in Far Eastern or Southern European subcontractors.*

On the other hand, according to the Senior Partner, some key long-term chip card suppliers have been selected due to the following factors:

- *Prime quality of the finished products. The countries where the products have been originated have centuries of craftsmanship tradition, with masters and apprentices.*
- *Strong moral and ethical concept. Some years ago, there was a case of ordered cards not meeting Aventura's thickness standard due to multiple coating of transparent film, thus they did not fit in one customer's card reader. The issue was brought directly to the supplier and new replacement products came promptly, free of charge and most importantly the procedure was hassle-free.*
- *Reliability and cooperative capability*
- *Availability of modules*
- *Close relationship with the OEM or a part of their inner circle.*
- *Technical support from an expert with whom you may have a direct communication with is widely available in Europe. According to the client company's experience, the communication with Far Eastern subcontractors is normally through their sales representatives, who tends to give the impression that they are manufacturers, but the operation turns out to be sales unit or an agency.*
- *Pre-set parameters and skills on pre-personalization*

The Senior Partner further described that:

*Aventura tends to gravitate towards a particular small-sized supplier because they seem to have similar wavelength. Another company offering similar range of products to the smaller competitor is a global*

*giant, with extensive organizational structure, which makes it a bit challenging to receive support in some issues and tends to offer long delivery times.*

Considering these aspects, it is beneficial to maintain a stable and well-managed long-term supplier relationship to receive a more streamlined supply chain operation and possible cost reduction.

### 3.5 Challenges of The Current Procurement Process

The challenges of the current procurement process as a part of Data 1 have been retrieved through method triangulation described in Table 1 – Data collection plan of Section 3.4. The challenges have also been identified through live IDI interviews, supplier questionnaire and ERP logs.

The discovered key challenges have been embedded in the procurement process map shown in Figure 10.

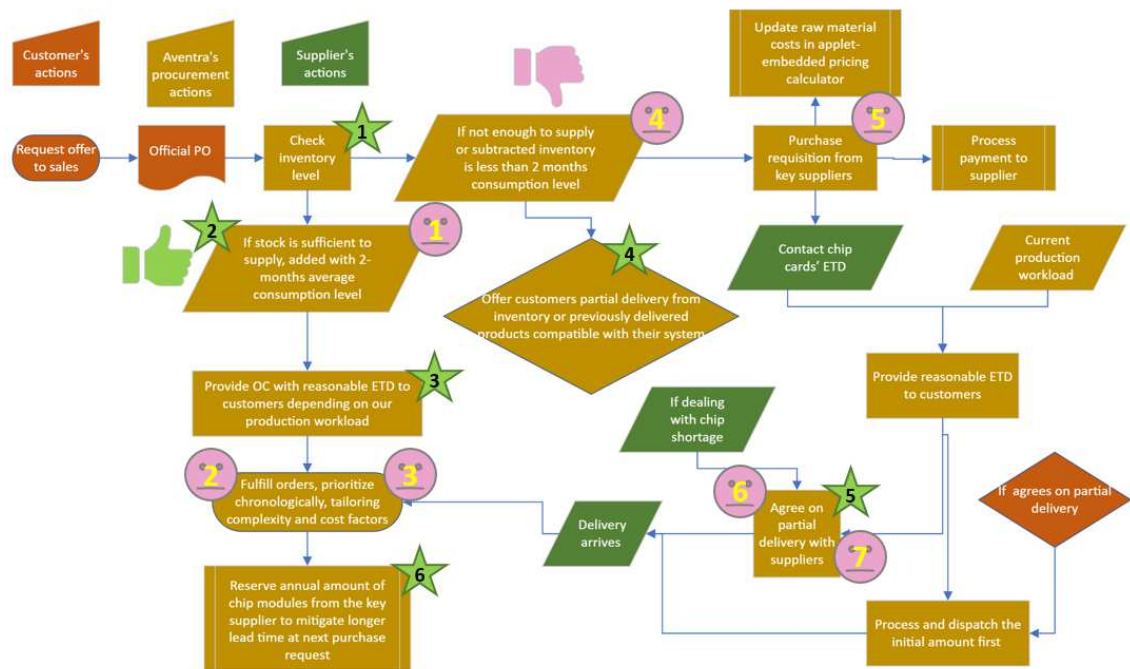


Figure 10 - Key challenges embedded in procurement process map.

The challenges shown in Figure 10 have been arranged according to the order of appearance in the procurement process flow. The challenges and their sources have been further dissected in Table 4.

Table 4 – Identified key challenges.

#	Challenges	Sources	Categorized and described in Section
1	Annual consumption level-based forecast is insufficient in providing real-life data.	IDI interview with the Senior Partner	3.5.1
2	It is highly demanding as it requires a lot of work effort, expertise, knowledge, and ability to analyse supply chain data.		3.5.1
3	No record on total rejected preforms from each production log (manual inventory subtraction).	Author's observation related to Figure 9.	3.5.3
4	MTO requests cause delays, where the products are tailored to the customers' specifications.	IDI interview with the Senior Partner	3.5.3

5	Limited number of contact chip suppliers.	Appendix 3	3.5.2
6	High dependency on key suppliers	Author's observation	3.5.2
7	The process is lacking systematic SLA (service level agreement) follow-up.	Author's observation	3.5.2

From the categorized challenges identified in Table 4, the author has decided to focus on encountering challenges number 5 – 7 covered in Section 3.5.2. The reason of selection is due to her capability to directly effect on the implementation of the prospected improvement in comparison to the other two categories.

The challenges will be further elaborated in Section 3.5.1, 3.5.2 and 3.5.3, and the solutions will be investigated through literature analysis based on best practices in Section 4 before proposing a preliminary partially developed model in Section 5.

### 3.5.1 Insufficient Forecast Data

According to the results of IDI interview with the Senior Partner, the author stated that the current protocol is to manually provide the ERP system a 2-months average consumption level to enable low stock level alert before processing a PO. Thus, it has been for a while observed that the annual consumption level-based forecast is insufficient in providing real-life data.

According to the Senior Partner,



*The 2 months average consumption level has been based on experience, where the average is calculated from annual sales log.*

The Management Role 1 strongly agreed to the author's preliminary proposal on researching a polished calculation model based on existing literature analysis and best practices to support Aventura's current procurement process.

Regarding the contact chip card procurement model, the Senior Partner added that:

*NXP informs their customers 1 year before they stop manufacturing a certain module, this is also the reason why the current protocol for contact chip card stock replenishment is based on one year demand. The prospect for JCOP3 looks good and it seems that they will still be supplied for a long time.*

The Senior Partner further specified that:

*The procurement model could also be based on forecast which products would turn into an actual PO. A polished calculation model would work if future sales or consumption can be predicted. Forecast model based on quarterly calculation could be created for each highly demanded product. Enough information can be obtained through market research.*

As another challenge to the procurement process, the Senior Partner added that:

*It is highly demanding as it requires a lot of work effort, expertise, knowledge, and ability to analyse supply chain data.*

### 3.5.2 Lack of SLA Follow-Up

In most cases, Aventura issues an invoice when the ordered goods or services have been delivered in full instead of opting for interim or pro forma invoices. When stumbled upon product scarcity which leads to supplier's partial delivery, this ethical practice delays invoice for being issued. Thus, the invoices could be held up for months during the procurement and partial delivery process to alleviate the customer demand.

According to the author's observation, the process is lacking systematic SLA (service level agreement) follow-up from suppliers, which contributes to a dependence to those suppliers who are also struggling with chip shortage issue. A quote might already be issued, which seems like the supplier has the product in stock. Upon purchase, they still might look around for compatible products and adjust the quote later based on that. Especially during stock scarcity when the lead time cannot be promised, Aventura might be informed that there is a certain amount of products up for quick grabs, though they might be gone upon confirmation. Due to the nature of embedded chip product, defect rate might be quite high, especially in some special card material like polycarbonate or composite of PVC/PETG.

The Management Role 1 agreed that Aventura would benefit from a delivery agreement model with chip suppliers with specifications corresponding to our quality handbook and standardized lead time, depending on the type of products supplied.

Potentially diversified supply chain base would also benefit Aventura Oy in times of scarcity.

### 3.5.3 Stock Reliability and Lead Time

One of the challenges according to the author's observation mentioned in Table 4 is that currently there is no built-in function which records total rejected preforms from each production log as observed in Figure 9. If the production team wants to keep the contact chip card inventory up to date, then the amount has to always be manually subtracted from each product code after each production run. This step might be deemed time consuming especially when the production runs over the capacity while meeting tight deadlines at times. The current procedure is to calculate the stock level of each product starting from the beginning of each fiscal year.

One of the author's improvement ideas would be for the production log window shown in Figure 9 to show both completed and rejected amount of cards going through applet embedding process. The amount of rejects could be retrieved from each card failing to go through the embedding process and entering the reject hopper instead of output hopper component of the card printing unit.

This feature would support the stock reliability and *taloushallinto* would be able to notify the scarcity on time before the production responsible has to inform the needs of procurement. This way the desired JIT inventory system becomes reasonable.

The sixth identified challenge in Table 4 is related to the time pressure caused by fear of delays due to semiconductor OEM's MTO (made to order) production strategy, where the products are tailored to the customer specifications. The

products are not necessarily available directly on demand as they are not MTS (made to stock), which matches inventory levels with anticipated demand.

The Senior Partner pondered whether:

*the public key has to be exactly customer-specific and suggests whether certain delivery-batch specific key would cut down the production time. The level of security would still be very high, because in any case the customers cannot download their own applets. The method suggested would cut down the needs to double check on the production workload, and therefore Aventura's process step of providing OC right after the first parallelogram shape in Figure 4 which specifies on the stock level sufficiency.*

### 3.6 Summary of The Key Findings

Data 1 results gathered from current state analysis uncovered many advantages and challenges of the current procurement process which have been pinpointed in each part of the procurement process map shown in Figure 11.

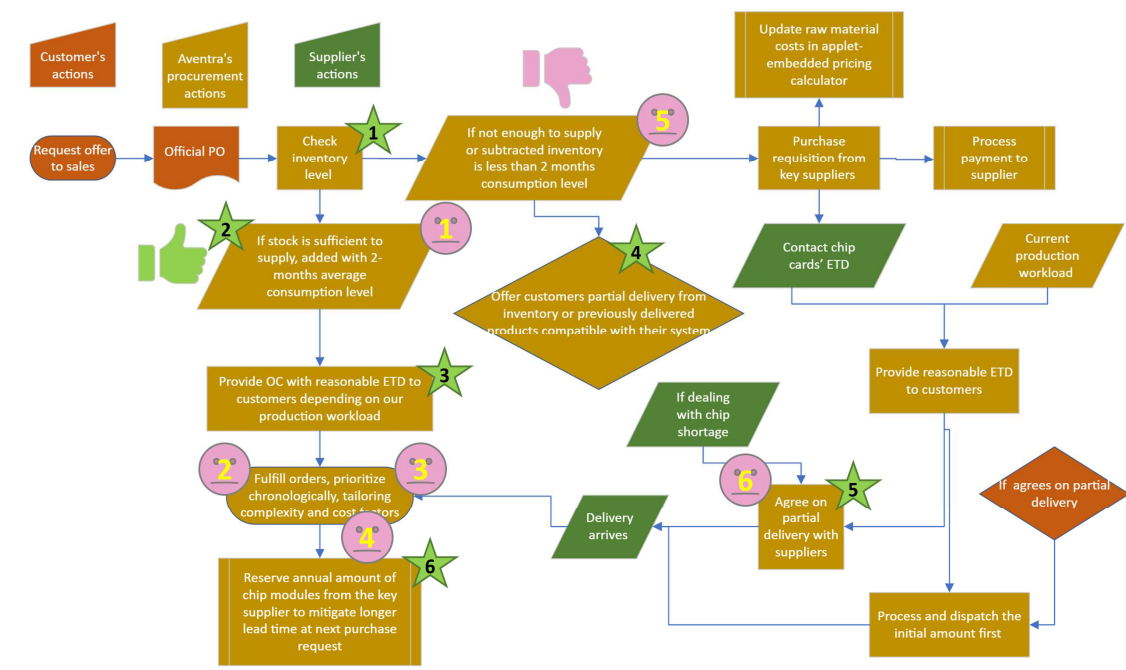


Figure 11 – Advantages and challenges embedded in procurement process map.

Table 5 provides a summary of Data 1 results from current state analysis stage compiled in Figure 7 – Total purchase of contact and hybrid chip cards each year from 2019 – 2022 Q3. The greens indicate advantages, whereas reds indicate the challenges. The main points have been ordered according to the results of categorization found in Table 3 and Table 4. These findings serve to guide the literature research in Section 4 of this thesis.

Table 5 – Categorized findings of the CSA

Category	#	Findings
<b>Forecast analysis</b>	1	Annual consumption level-based forecast is insufficient in providing real-life data.
	2	It is highly demanding as it requires a lot of work effort, expertise, knowledge, and ability to analyse supply chain data.
<b>Supplier coordination</b>	5	Limited number of contact chip suppliers.
	6	High dependency on key suppliers
	7	The process is lacking systematic SLA (service level agreement) follow-up from suppliers.

<b>Stock and lead time</b>	3	No record on total rejected preforms from each production log (manual inventory subtraction).
	4	MTO requests cause delays, where the products are tailored to the customers' specifications.
<b>Advantages</b>	1	Manageable with a smaller storage space
	2	Improve cash flow, as cash is not tied up in inventory
	3	ERP system is developed in house. New functional features are implemented fast.
	4	Optimally as many inventory products as possible are still on-demand
	5	It enables direct delivery from stock as often as possible due to close cooperation with reliable partners.
	6	ERP's production status registers how many applets have been embedded in each order stage.

The first challenge category is related to the currently imperfect forecast based on annual consumption level, which would likely be improved with demand forecast analysis. The second category concerns how the suppliers are

currently coordinated. Improvements from literature are sought to create a delivery agreement model to benefit Aventra and its most loyal suppliers. The third category is related to stock and lead time reliability.

This summary completes the CSA stage of this study. Section 4 investigates existing knowledge discovered in academic literature and its best practices to tackle the supplier coordination category from the current procurement process challenges described in this section.

## **4 Procurement Process Improvement Ideas from Relevant Literature**

Section 4 assembles the applicable best practices discovered through literature analysis and formulates them into the conceptual framework of thesis study. Applicable literature was searched to eliminate the identified key challenges presented on Table 4. The summary of findings was grouped into three categories.

In order to facilitate a more in-depth literature analysis to provide potential solutions to the identified challenges, the categorized set of challenges presented in Section 3.5.2 has been separated into three subsections in Section 4. Each subsection elaborates the description of the relevant potential solution, followed by a discussion and relevance justification to this study.

Section 4.4 completes this section by displaying a graphical summary as the most essential information for this study, the conceptual framework.

### **4.1 Enhancing Key-Supplier Relationship Management**

Due to the similar wavelength to long-term key suppliers described in Appendix 1 and Aventra's loyalty to the key supplier described in quality handbook Section 5.4. Enhancing key-supplier relationship management has been chosen as the leading focus to potential improvement proposal.

Through his multiple case study, Toivanen (2017: 1-15) introduces the following supply chain strategy to adapt to volatility:

- Increasing supply chain flexibility or resilience. The company must be able to survive and recover from unanticipated changes without sacrificing its delivery capacity and profitability. The company must be able to identify, monitor, and eliminate supply chain risks and disruptions, as well as react quickly and cost-efficiently to supply chain changes (Melnik, et al., 2010).
- Enhancing collaboration and communication with suppliers and customers. Long-term supplier selection is influenced by the quality of customer relationship. The “use where produced” principle influences supplier selection. Global market dominance is attained by a strong brand, high-quality items, excellent customer service, and fast deliveries. Sales strategies emphasise solution sales, which aims to discover the right products, information, and maintenance services for a specific customer. Customer service therefore requires high technical expertise. The customer’s perception of quality and customer-centric service determines success. Companies seek to boost competitiveness by enhancing product development and customer orientation.
- Technology and automation investment. Company’s competitiveness is guaranteed by continuous product development and innovation, as well as the ability to produce sufficient capacity. Core competencies should be acknowledged and utilized in business operations. Processes should always be enhanced by every production site to sustain performance (Altay & Ramirez, 2010). According to Voss, best practices frequently reduce down to “world-class manufacturing”, including continuous improvement, just-in time (JIT), lean, total quality management (TQM) benchmarking, activity-based costing (ABC), concurrent engineering (CE), and business process re-engineering (BPR) (Laugen, et al., 2005).



- Risk management. To sustain the business operations, business environment volatility must be comprehended; resilience capability and robustness have to be developed in rapidly evolving sectors (Sabet, et al., 2017).
- Contingency plans through demand forecasting associated largely with sales and order planning (S&OP). Supply chains are built on lean strategy, especially in the manufacturing sector where they aim to be pull-based or customer-driven, although their production management is push-based and S&OP forecast-driven. IMS is emphasized in keeping material flows under control through ABC analysis of various turnover rates in high service level, where they are viewed as a tool to swiftly meet customer demand. The planning cycle is governed by customer requirement (Toivanen, 2017).

From the most essential supply chain strategies mentioned above, this section focuses particularly on enhancing collaboration with long-term key supplier through best practices on key-supplier relationship management and developing an SRM framework and supplier coordination mechanisms.

#### 4.1.1 Key-Supplier Relationship Management Practices

Miocevic & Crnjak-Karanovic (2012) reveal that key supplier relationship role and its connection with purchasing performance are inadequately acknowledged in the present B2B marketing literature. Considering the prevalence of collaborative supply chain relationships, purchasing must be seen as value providing, indicating its efficacy. Effective purchasing behaviour is measured by organisational buying effectiveness (OBE). The association between SCO (supply chain orientation) and OBE is mediated by KSRM (key supplier relationship management).

KSRM focuses on the management of strategic relationships and assumes that a company's portfolio consists of multi-level significant partnerships (Ivens, et al., 2009). Relationships cannot be addressed in a "one-size-fits-all" manner;

companies must differentiate between key strategic and transactional partnerships (Lambert, 2004).

According to Miocevic & Crnjak-Karanovic (2012), KSRM is defined as the proactive management of continuing commercial relationships with key suppliers. Giannakis (2007) argued that to reveal suppliers' actual value, companies must monitor their performance. Pressey, et al. (2009) discovered that companies evaluate the key suppliers' performance with a strategic purchasing approach.

Miocevic & Crnjak-Karanovic (2012) hypothesised that a substantial relationship exists between KSRM and OBE for the following reasons:

- 1) Companies implement KSRM to handle purchase procedures more efficiently. Yet, strategic suppliers earn their key status since they contribute value-adding functions and products in the procurement exchange processes.
- 2) Strategic supply chain relationships must match strategic internal relationships, for example within the company's purchase centre (Piercy, 2009).

Based on the qualitative research findings by (Wagner & Johnson, 2004), (Miocevic & Crnjak-Karanovic, 2012) identified three KSRM dimensions:

- 1) Planning: Ulaga & Eggert (2006, p. 131) argued that:

*" Offering superior benefits to the customer is essential for winning a substantial share of the customer's business."*

Key suppliers achieved their position by delivering extraordinary value to their clients through benefits enhancement and/or costs reduction. Oftentimes OEM key suppliers' strategic inputs (e.g., raw materials,

components, or systems) become the customer's product offering's fundamental components.

- 2) Implementation: KSRM as a fundamental organisational process which creates the managerial framework (from planning to control mechanisms) for managing key suppliers.
- 3) Control: The customer can monitor the strategic suppliers' value stream and respond accordingly in case of mishap. Thus, KSRM is a significant source of company competitiveness (Hunt & Davis, 2012) (Sheth, 1996).

According to Miocevic & Crnjak-Karanovic (2012), suppliers should be classified based on their added value to the purchaser. A management framework for key supplier relationships is necessary for the following reasons:

- 1) To monitor the nature of the value flow within transaction.
- 2) To maintain and nurture key supplier relationships.

Miocevic & Crnjak-Karanovic (2012) advises companies to invest more in purchasing and supply management (e.g., processes, resources, staff, and capabilities) to implement KSRM. Key suppliers are accountable for the essential inputs that a manufacturer incorporates into its value proposition. From a pragmatic standpoint, SCO will be more relevant to management when a KSRM system and efforts are implemented. Businesses may extract more upstream (purchase) value, hence enhancing purchasing process efficiency.

#### 4.1.2 Supplier Relationship Management Framework

Moeller, et al. (2006) constructed a framework for Supplier Relationship Management (SRM) as a systematic approach that companies can use to manage their relationships with suppliers in order to achieve mutual benefits.

From the main findings gathered, the sequential SRM phases were summarized into Figure 12.

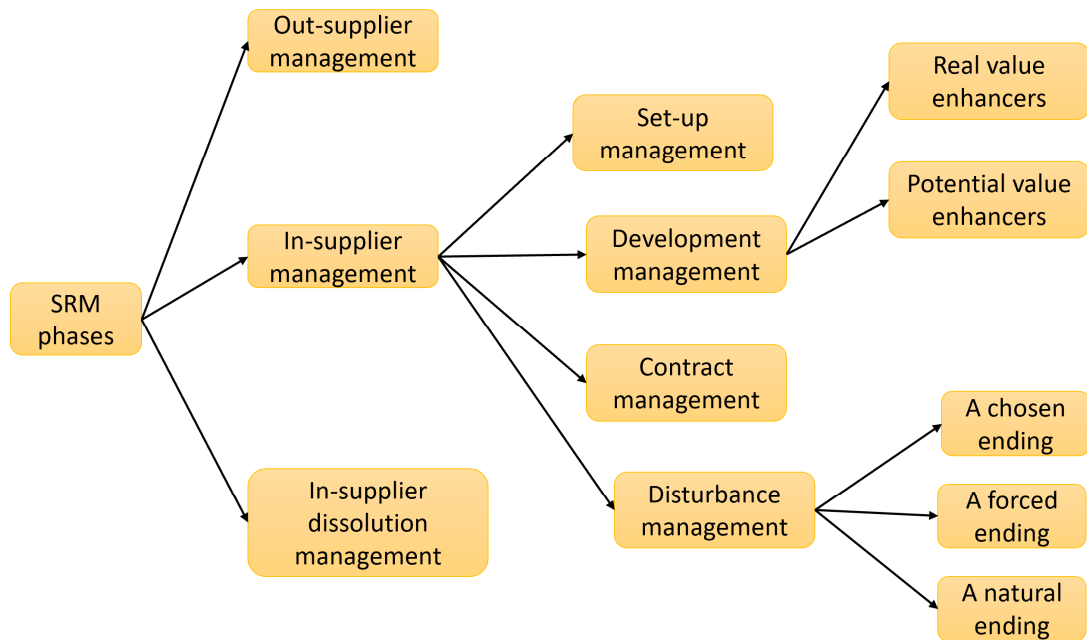


Figure 12 – Main SRM phases created from (Moeller, et al., 2006).

SRM can be segmented into the following three consecutive phases:

- 1) Out-supplier Management for suppliers with whom the purchasing company has no current contact with. The goal of Out-Supplier Management is to maintain ties with the market's finest suppliers, as the existing condition of a partnership should never be regarded a permanent solution (Gadde & Snehota, 2000). This involves assessing and acquiring out-suppliers. Out-Supplier Management must be viewed as costly, particularly because assessing out-suppliers is more difficult than assessing in-suppliers since less information is available. Purchasers must ensure that the benefits of Out-Supplier Management endure throughout time.
- 2) In-supplier management for suppliers whose status has changed after their first transaction with the company. The objective of In-Supplier Management is to establish and maintain relationships with in-suppliers in order to

enhance value creation. Owing to the suppliers' varied potential to enhance value, the relationship phase has been segmented into:

- a. The purpose of Set-Up Management is to build the partnership from the very start. CRM literature and transaction cost theory imply that establishing a connection with a new supplier might be valuable and necessary (Dyer, et al., 1998), (Hogan & Armstrong, 2001), (Sheth, 1996). As a result, Set-Up Management requires specialised investments from both the supplier and the purchasing company, whereas mutuality protects them (Jap, 1999).
- b. Development Management ensures a permanently enduring valuable relationship through identification, evaluation, and operations enhancement in prospective areas.
  - i. Suppliers with a high relationship contribution, or "Real Value Enhancers," are typically the topic of high-level development management initiatives. This is owing to the fact that the purchasing company must retain these suppliers and ensure that they neither switch to competitors nor terminate their partnership.
  - ii. Strategically significant suppliers who are currently contributing at a low level are "Potential Value Enhancers." They can still be the focus of development management initiatives since they may contribute at a greater level throughout the course of a prosperous partnership.
- c. Contract Management, where the desire to invest on the buyer's side cannot be assumed by the supplier relationship (Dyer, et al., 1998), even if the supplier is strategically significant. For such a partnership, processes for external monitoring of largely output-focused jobs must be in place (Heide, 1994).

- d. Disturbance Management which serves to stabilise the continuous relationship. Various factors, such as bankruptcy or the natural demise of a product type, might bring an end to a continuous relationship, without the partners' ability to take preventative measures. Thus, three types of terminations may be differentiated for continuous relationships:
    - i. A deliberate ending, in which one party takes the initiative to end the relationship.
    - ii. A forced ending, which is imposed by external circumstances.
    - iii. A natural ending, implying that the need for business trade has gradually become obsolete (Halinen & Tähtinen, 2002).
- 3) In-supplier dissolution management addresses that an undesired relationship must be severed for whichever cause. Cross-functional teams are formed to simplify the supplier base. Supply base reduction reasons are:
- a. Quality and service enhancement
  - b. Entering long-term agreements
  - c. Devoting efforts to top suppliers.
  - d. Establishing partnerships
  - e. Becoming more customer-centric

(Institute of Management and Administration, 2002).

#### 4.1.3 Control and Coordination Mechanisms

Mantere (2015) assesses the use of control and coordination mechanisms used in a supplier-purchaser relationship and how the collaboration from both parties

is managed from the purchaser's perspectives. Diverse alliances and inter-firm partnerships are becoming more prevalent in the modern corporate environment; therefore, understanding how alliances should be managed is a crucial skill in the modern business environment.

Three theoretical frameworks were featured in the study:

- 1) The first framework at a higher level consisted of coordinating mechanisms. Bartlett & Ghoshal (1998) assert that in an extremely dynamic market environment of contemporary business, multinational corporations (MNC) must simultaneously confront and solve these strategic challenges: global efficiency, local responsiveness, global learning.

Three coordinating mechanisms have been outlined to manage those challenges: formalization, centralization, and socialization.

Aubey, et al. (1989, p. 115) examined the challenges of global integration and local responsiveness and characterised the management instruments for addressing these pressures as data management, manager motivation, and dispute resolution.

- 2) The second higher level framework consisting of two major control archetypes such as:
  - a. Hybrid exploratory control archetype, which calls for low programmability. Relevant characteristics to this study including:
    - i. Outsourcing with a restricted number of suppliers.
    - ii. Typical supplier ranking; implicit but credible.
    - iii. Contract renewal promises.
    - iv. General contracts.

- v. Strong cooperation and shared responsibility.
  - vi. The flow of information facilitates cooperation.
  - vii. Performance evaluation based on evolving standards.
- b. Hierarchical arm's length control archetype, which requires high programmability. Relevant characteristics to this study including:
- i. No full outsourcing, added with in-house production.
  - ii. Mostly dependent on market mechanisms.
  - iii. Performance assessment relative to competitors.
  - iv. Intervention strategies in the event of unexpected performance.
- 3) The third is a detailed framework based on an inter-firm management control systems (MCS) package, constructed by utilizing MCS control package from (Malmi & Brown, 2008, pp. 287-300) as a basis, which includes five types of MCS including cultural, planning, cybernetic, reward and compensation, and administrative controls. The details are found in Table 6.

Table 6 - Bundled management control systems (Malmi & Brown, 2008) (Mantere, 2015)

<b>Cultural controls</b>						
Clans		Values			Symbols	
<b>Planning</b>		<b>Cybernetic controls</b>				<b>Reward and compensation</b>
Long range planning	Action planing	Budgets	Financial measurement systems	Non-financial measurement systems	Hybrid measurement systems	
<b>Administration controls</b>						
Governance structure		Organization structure			Policies and procedures	



Describing elements found on Table 6, cultural controls are very much important for inter-organizational relationships where the task programmability and outcome measurability are low (Das & Teng, 1996) (Van der Meer-Kooistra & Vosselman, 2000). Frequently mentioned cultural control methods in inter-firm MCS studies are participatory decision making (Das & Teng, 1996) (Dekker, 2004), developing shared interests and building an expectation of mutual reciprocity and cooperative conflict resolution (Das & Teng, 1996) (Zajac & Olsen, 1993). These strategies increase confidence and ensure that all participants understand each other's motives.

Planning within an inter-organizational context is enabled through contracting (Ding, et al., 2013) and interactive planning between alliance partners (Gietzmann, 1996). According to Dekker (2004) and Van der Meer-Kooistra & Vosselman (2000), long-term planning and structure can be incorporated to a contract, whereas action plans can be developed through collaborative decision. Hart & Moore (1990) explored the concept of incomplete contracts and the consequence of not being able to foresee future contingencies. Long-term plans are more likely to be integrated into the contract than short-term ones (Coad & Cullen, 2006) (Dekker, 2004). Short-term planning includes deciding on short-term objectives, developing strategies (Dekker, 2004) and establishing timetables (Möller & Rajala, 2007). Long-term objectives may include creating collaborative innovation or expense reduction, while short-term ones may include quality plans for product or process development (Dekker, 2004). The fundamental objective of the planning may be to guarantee that cooperation yields beneficial outcomes (Das & Teng, 1996) and to improve coordination (Dekker, 2004)

Malmi & Brown (2008) explain that cybernetic control techniques are used to measure and compare specified goal output, and to adjust the activity or system to better align it with the targets based on the identified variance. In MCS package, cybernetic controls usually include budgets, financial and non-financial measurements, and their hybrid like balanced scorecards.

Reward and compensation in buyer-supplier interactions are often based on supplier rank according to their performance, with the reward being tied to the supplier's current rank (Cooper & Slagmulder, 2004). The objective of reward or compensation may motivate performance improvement (Gietzmann, 1996), promoting transparency and reciprocal behaviour (Dyer, et al., 1998), or reducing appropriation concerns and relationship risk by aligning partners' interests and negotiating the distribution of benefits (Anderson, et al., 2014) (Dekker, 2004). Further opportunities may be created through these incentives, for example transparency and reciprocal behaviour may enhance learning within the alliance (Dyer, et al., 1998).

According to Malmi & Brown (2008), administrative control systems consist of organisation and structure, formal processes and regulations, and associated monitoring systems which define and direct staff behaviour. Additional administrative control measures that are strongly tied to organisation structure include defining decision rights and overall responsibilities (Anderson, et al., 2014).

(Mantere, 2015) argues that there was a definite advantage to employing many theoretical frameworks, as they mutually assisted the discovery of the key findings.

## 4.2 Supplier Diversification Practices

(Do, 2022) issued a wake-up call for businesses to reconsider their supply chain agility in this ongoing semiconductor shortage that has widely disrupted companies' supply chain operations and finances. Due to the unpredictability and severity nature of the shortage, supply chain agility is essential for managing supply interruptions. Each guideline to alleviate each semiconductor shortage phase is described in Figure 13.

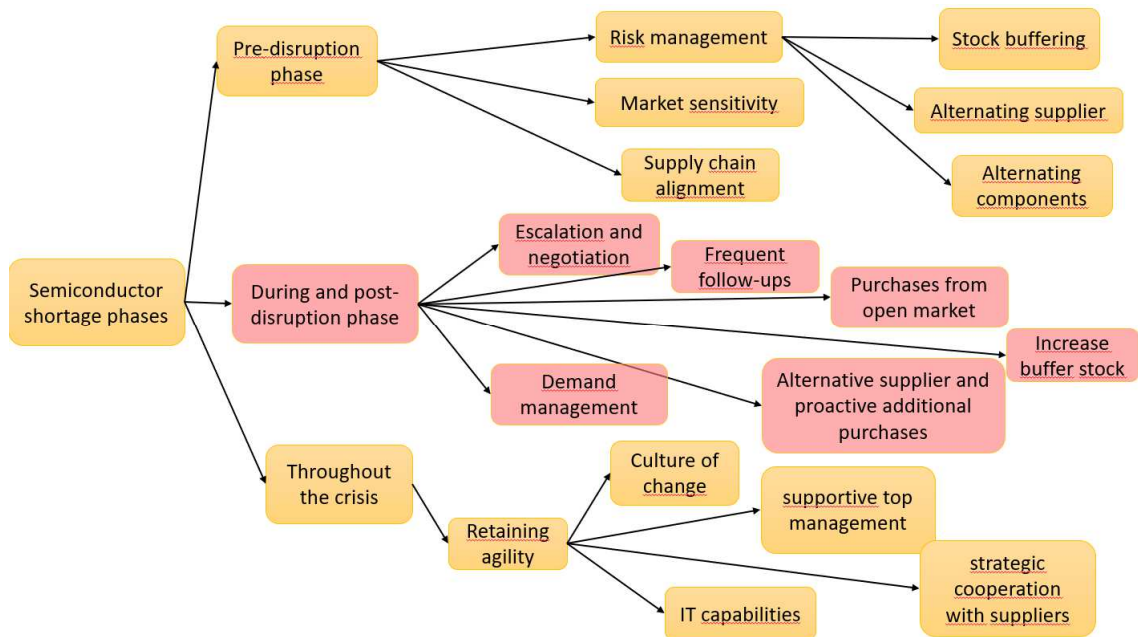


Figure 13 – Guidelines to alleviate each semiconductor shortage phase, devised from Do's (2022) findings.

Figure 13 includes guidelines to alleviate each semiconductor shortage phase. Each one has been described as follows:

- 1) Pre-disruption phase: Successful deployment of proactive initiatives in this period demands vigilance and accessibility supported by the following elements:
  - a. Risk management with different approaches as buffering stock requirement, employing alternative suppliers (up to four for the same component) and utilizing alternative components which requires R&D agility to test on alternative materials.
  - b. Market sensitivity is a critical precursor for supply chain agility; without it, a company's supply chain would struggle to capitalise on market opportunities and adapt operations in reaction to changes (Aslam, et al., 2018). Market sensing skills enables companies to comprehend supply chain partner operations (Tse, et al., 2016), capture market data, and identify key patterns required in resource planning (Aslam, et al., 2018).

End-to-end visibility of the supply chain is crucial for vigilance, as it provides awareness to the current state of supply and demand, procurement, production, and inventories (Christopher & Peck, 2004).

- c. Supply chain alignment. ERP systems handle end-to-end information flows and monitor the most recent state of various supply chain operations.
- 2) During and post-disruption phase: In addition to operational flexibility and demand management, employing existing risk management practices enables rapid and flexible responses to unanticipated supply changes. Rehabilitation strategy is essential to foster long-term crisis-related learning. The following post-disruption responses have been implemented by companies:
- a. Escalation and negotiation to deny any postponement or request for improvement.
  - b. Frequent follow-ups via active discussions with clients, regular meetings, and daily conversations with suppliers.
  - c. Purchases from open market in order to boost performance.
  - d. Increase buffer stock by altering system parameters, boosting safety stock levels, expanding purchase sizes, and compromising inventory rotation. Customers are advised to use a similar strategy to assure delivery accuracy during the shortage.
  - e. Alternative supplier and proactive additional purchases from local markets.
  - f. Demand management identifies which customers require the items first depending on various variables, such as contract penalties.

- 3) Throughout the whole crisis: Retaining agility in the timespan of crisis necessitates a culture of change, supportive top management, strategic cooperation with supply chain partners, and information technology capabilities.

From the supplier diversification practices, linking import diversification with quality search, multinational supplier selection criteria in volatility era, and spotting potential suppliers with similar products under discreet demand have been chosen for further elaboration in the following subchapters.

#### 4.2.1 Import Diversification with Quality Search

Cadot, et al. (2014) examined the link between an OECD (The Organization for Economic Cooperation and Development) country's imports and its efforts to diversify its suppliers and search for higher quality products.

By using data from 24 OECD nations from 1996 to 2006, Cadot, et al. (2014) explored the variables that influence a country's decision to import from an exponential number of countries and to seek out higher quality products. Countries with more trade openness tend to import from a larger number of suppliers, and countries with higher income levels are more likely to import items of higher quality.

Cadot, et al. (2014) investigated the role of trade agreements in promoting diversification and quality search. Countries that are members of many trade agreements tend to import from a greater range of suppliers, and trade agreements can encourage countries to seek out products of higher quality.

Ultimately, Cadot, et al. (2014) suggests that import diversification and quality search are crucial tactics for countries seeking to boost their prosperity through international commerce. Cadot, et al. (2014) emphasised that trade agreements can play a role in supporting these strategies but advise policymakers to be aware of the potential costs associated with these efforts, such as increased complexity and administrative burden.

#### 4.2.2 Multinational Supplier Selection Criteria in Volatility Era

Mahsa, et al. (2019) focused on the decision-making processes of a multinational supply chain under uncertain conditions. The research provides a model that incorporates pricing, promised delivery lead time, supplier selection, and ordering choices of a multinational supply chain. Mahsa, et al. (2019) analyse the influence of supply and demand uncertainty and fluctuating currency rates on supply chain's decision-making processes.

Mahsa, et al.'s, (2019) findings imply that upon facing demand fluctuation, the supply chain should select numerous suppliers with varying lead times to provide a constant commodity supply. Mahsa, et al. (2019) discovers that fluctuating exchange rate remarkably impacts pricing and supplier selection decisions, with companies choosing suppliers from lower exchange rate countries.

Mahsa, et al. (2019) recommend that companies assess fluctuating exchange rate's impact on their ETD and alter their purchase decisions accordingly. Companies with actively implemented risk prevention measures tend to choose suppliers with shorter lead times and higher pricing.

#### 4.2.3 Potential Suppliers under Discreet Demand

Discreet or discontinuous demand features products with elevated demand quantity as soon as the market price drops. Swaminathan & Shantikumar (1999) recommends the need to identify the ideal number of providers that a company should utilise to satisfy their demand requirements in a discrete demand environment.

Swaminathan & Shantikumar (1999) identified the difference between two demand conditions:

- 1) Continuous demand: The optimal number of suppliers is defined by the trade-off between supply risk and transaction costs.

- 2) Discontinuous demand: The optimal number of suppliers is not a continuous function of demand and might abruptly vary as demand increases.

Swaminathan & Shantikumar (1999) recommend that companies should compare the advantages (decreased supply risk) to the administrative and transaction expenses of diversified supplier base in discrete demand to identify the optimal number of suppliers to employ.

### 4.3 Delivery Terms Agreement Model Creation Plan

The following subchapters contain literature analysis that would assist the author in creating delivery terms agreement model for suppliers. The first subchapter analyses logistics service contracts, their practical designs, and penalties for non-performers. The second subchapter consists of inventory SLA as coordination mechanisms and bullwhip effect reduction. The third subchapter involves supply chain strategies and their execution model.

#### 4.3.1 Logistics Service Contracts Overview

Lowe (2007, p. 318) defines contract as an arrangement between parties in which they are required to fulfil their commitments in exchange for a compensation. If control cannot be exercised directly over supply chain parties (Wang, 2002), supplier coordination can be achieved through incentives (Rafiq, 2004). Contracts regulate lead time and on-time delivery (Forslund, 2009). Utilizing contracts measured by fill rate throughout supply chain enhances LSP (logistics service performance) (Chan & Chan, 2005).

Formalization through contract regulates working interactions by standard processes (Daughtery, et al., 1992) or the presence of formal rules, procedures, and policies (Dröge & Germain, 1989). Formalization improves performance by reducing uncertainty and routinizing processes (Daughtery, et al., 1992). Higher levels of formalization are associated with enhanced logistical performance (Dröge & Germain, 1989) (Daughtery, et al., 1992). Performance improvement

is observed from evolving contracts rather than those defined at the beginning of a relationship (Chopra & Meindl, 2007).

Multiple contract documents with distinct formats are always utilised (Wang, 2002). Formalization degree varies according to standardized rules and procedures (Dröge & Germain, 1989). Formalized instances perceived a higher LSP level (Daugherty, et al., 1992). Larger organisations are anticipated to have a higher degree of formalization. Many customers manage performance with ISO standards. Improvement benefits are achieved with a low-level formalization contract employing even the least structured scenario.

According to Forslund (2009), LSP is influenced by supplier's capabilities and goals and the customer's purchasing behaviour and expectations. Figure 14 depicts PM (process management) activity flow.

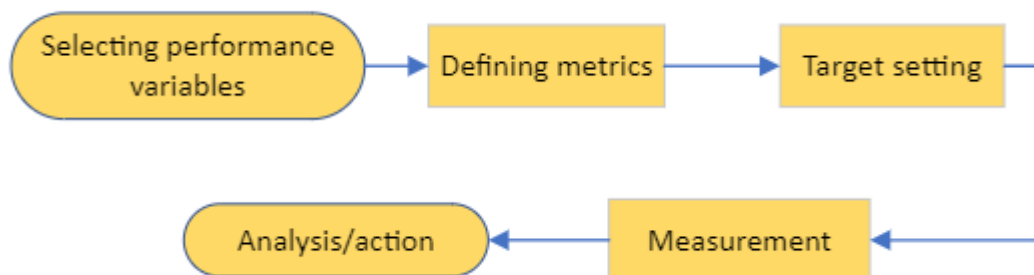


Figure 14 – PM activities, generated from (Forslund, 2009) article.

Forslund (2009) argues that contract enhancements may include incentives or penalties. As penalties appear to be the more prevalent approach in improving contract effectiveness. The types of incentives and penalties can be observed in Table 7.

Table 7 – Types of incentives and penalties, derived from (Forslund, 2009).

#	Incentives	Penalties



1	Cost	Refund of all expenses, or even added with acceptable profit.
2	Schedule: Contract where the client incentivizes on-time delivery (Grout & Christy, 1993).	Late delivery: Predetermined sum that the supplier needs to pay. Assuming the possibility of estimating the incurred loss (Lowe, 2007).
3	Performance: Supplier reward for performing above the agreed targets. (Van Weele, 2005)	

In spirit of designing a commercial contract, Lowe (2007) emphasizes a required degree of flexibility for all parties involved. It is impossible to implement penalties if the customer is a part of the problem. Contracts must also be clear, fair, transparent, straightforward, and designed to encourage collaboration through excellent management (Latham, 1994). On-time delivery is an essential performance metric to include in a contract since orders are seldom altered throughout the supply chain. In contrast, when orders vary often, delivery flexibility is a contract appeal (Jammernegg & Kischka, 2005).

Forslund (2009) separated PM process for contracts into the following sub-processes:

- 1) Setup phase: A single unified and integrated process between the customer as the regulator and the supplier by agreeing performance variables selection, applicable metric definitions, and set targets. Setup details specify how measurement, analysis, and action should be performed further. The setup phase minimizes time and effort spent on disputing various LSP metrics definitions.

- 2) Execution phase: After the infrastructure has been established, all resources were focused on measuring, analysing, and improving LSP; facilitated by the contract document. Operational PM tasks become shorter and simpler, and the coordination of transaction-related activities is enhanced (Hsu, et al., 2008).

#### 4.3.2 Inventory SLA as Coordination Mechanisms

Katok, et al. (2008) investigated the impact of inventory SLA on supply chain member cooperation. The investigation focused, in particular, how the length of the review term for these agreements influences inventory levels, order amounts, and supplier performance.

Katok, et al. (2008) created a three-tiered supply chain model, including a retailer, a distributor, and a supplier. A simulation was employed to determine how inventory SLA review times effect supply chain performance. As retailers and distributors seek to maintain excellent service levels in the face of unpredictable demand, they discover that shorter review periods result in greater inventory levels and lower order volumes. Yet, shorter review periods can result in improved supplier performance, since suppliers are able to respond more promptly to demand fluctuations.

Katok, et al. (2008) indicated that the effect of review period length on inventory levels and order volumes is dependent on demand volatility. Because demand is highly variable, shorter review intervals result in greater inventory levels and smaller order quantities, whereas longer review periods result in greater order quantities and lower inventory levels. Shorter review period also leads to better performance by reducing the supply chain bullwhip effect, which is characterized by the unpredictability order to supplier resulting in magnified upstream demand variability. It is essential to bear in mind that frequent monitoring and ordering will increase cost.

### 4.3.3 Supply Chain Strategies and Execution Model

Christopher & Towill (2001) suggests the importance of customer satisfaction and market knowledge when developing a new supply chain strategy. When the criteria and limits of the marketplace are comprehended, a company may attempt to build a plan that meets the needs of the competitive supply chain and the end client. Survival in the marketplace is defined by the end consumer, and the objective is to obtain the right product at the right price at the right time.

Due to supply chain uncertainty which prevails in tailor-made products where the demand is naturally unpredictable, Christopher & Towill (2001) recommend companies to develop a strategy to match supply and demand to lower costs while improving customer satisfaction.

Manufacturing and supply chain strategies that should be considered before planning delivery terms agreement model are market qualifiers and winners as depicted in Figure 15. Market qualifiers is the baseline for entering into a competitive arena. Whereas order winners are the specific capabilities that are required to win the order. By nature of competition, last year's market winner is replaced this year by a former market qualifier. The market winner rotates between quality, cost, availability, and lead-time.

Agile Supply	<ol style="list-style-type: none"> <li>1. <u>Quality</u></li> <li>2. <u>Cost</u></li> <li>3. <u>Lead Time</u></li> </ol>	<ol style="list-style-type: none"> <li>1. <u>Service Level</u></li> </ol>
Lean Supply	<ol style="list-style-type: none"> <li>1. <u>Quality</u></li> <li>2. <u>Lead Time</u></li> <li>3. <u>Service Level</u></li> </ol>	<ol style="list-style-type: none"> <li>1. <u>Cost</u></li> </ol>
Market Qualifiers		Market Winners

Figure 15 – Differences between lean and agile paradigm based on market qualifiers and winners (Christopher & Towill, 2001)

Another factor that should be considered before establishing delivery terms agreement model is the supply chain total PDP (product delivery process) costs as depicted in Equation 1.

Equation 1 - Supply chain total PDP (product delivery process) costs  
(Christopher & Towill, 2001)

Supply chain total PDP costs = Physical PDP costs + Marketability costs

- Physical PDP costs dominate lean supply and include all production, distribution, and storage costs. Excessive lead-time and cost are waste.
- Marketability costs dominate agile supply and include all obsolescence and stockout costs. Service level (availability) is the critical factor in agility.

Three practical ways of combining lean and agile paradigms:

- The Pareto curve approach. 80% total volume is generated from 20% of the total manufacturing line. The top 20% should be managed according to lean, because the volume is more predictable. The slow moving 80% requires agile management due to less predictability.
- The de-coupling point approach holds inventory strategically in some generic or modular form and only complete the final assembly or configuration when the precise customer requirement is known. Lean is enabled up to the postponed de-coupling fulfilment point, and agile happens afterwards.
- Separation of base and surge demands, where capacity demands are smoothed by intelligent schedule switching. Base demand is forecasted from past history and is met through classic lean procedures. Surge demand is provided through flexible, and higher cost processes. Base demand is typically sourced in low-cost countries and the surge demand is topped up

near the market. The advantage lies in supply chain rather than unit cost of manufacturing.

(Christopher & Towill, 2001)

This subchapter completes the in-depth literature analysis assessment of each identified challenges that has been categorized into supplier coordination as classified in Table 5 – Categorized findings of the CSA Section 4.4 presents the conceptual framework as the most essential element of this study.

#### 4.4 Conceptual Framework of The Study

Figure 16 compiles and presents the major themes of literature implemented in this study into a graphically compact format.

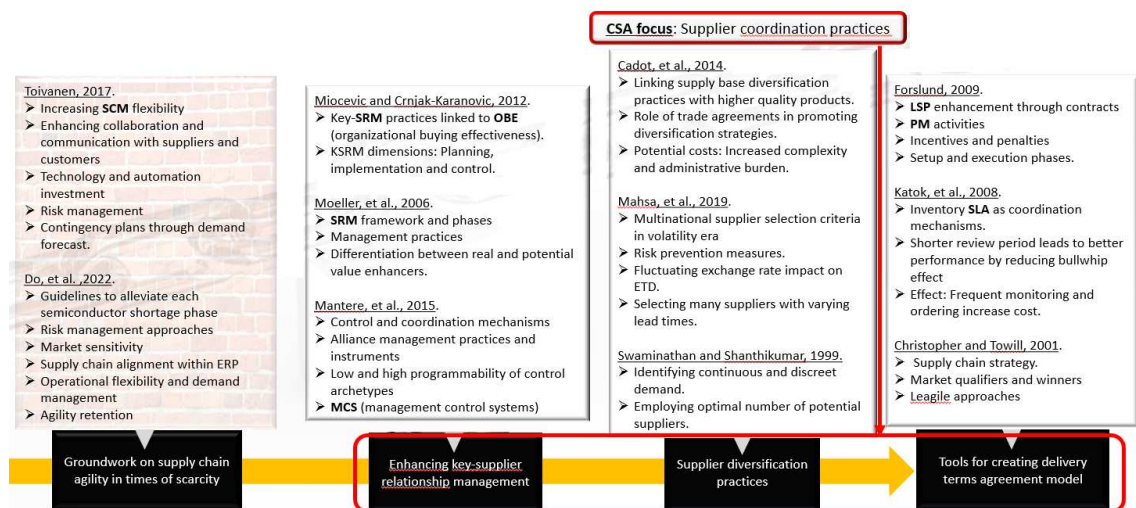


Figure 16 – The conceptual framework of this thesis study.

As observed in Figure 16, the conceptual framework is separated into three distinct categories according to the logic of the current state analysis findings. The leftmost box being the groundwork for building the solutions to enhance supplier coordination practices covered in the introduction portion of Section 4.1 (Enhancing Key-Supplier Relationship Management) and Section 4.2 (Supplier Diversification Practices). The combined second and third portion from the left

help create Section 4.3 (Delivery Terms Agreement Model Creation Plan) on the furthest right.

The conceptual framework developed in this section combined with CSA findings presented in Section 3 form the basis of building the initial proposal of a refurbished action plan for contact chip procurement in the following section.

## **5 Initial Action Plan Proposal to Partially Improve the Procurement Process**

The initial proposals are formulated in Section 5 by combining the advantages gathered in the current state analysis with the conceptual framework to tackle the challenges presented in the current state analysis. This section provides an overview of the stage, summary of action plan proposals, and a comprehensive description of the creation process.

### **5.1 Overview of the Initial Proposal Creation Stage**

The objective of this master's thesis work is to propose actions to improve Aventura's contact chip procurement process during global chip shortage. The initial proposal creation stage was carried out with the Senior Partner due to the respondent's direct role in enabling prospective functions related to procurement process improvements within the ERP system. The author actively participated in the solution building workshop for the initial proposal due to her responsibility in covered areas such as sales, procurement, and supply chain.

In order to steer the focus due to the limited time available for the solution building workshop, a copy of Section 3, the current state analysis and Section 4, the conceptual framework along with the reference list was sent to the Senior Partner as a suggested pre-reading material some days prior to the session. Section 3 largely consists of anecdotes gathered from the IDI live interview with the Senior Partner as reported in Appendix 1.

The 2,5 hours solution building workshop was conducted in Aventra's meeting room as IDI live interview. All the findings gathered in current state analysis to tackle the challenges utilizing solutions found on literature review were further assessed to find the solutions which would best fit the organization. The respondent provided a lot of precious industrial insights.

The complete raw field notes from the solution building workshop are documented in Appendix 5. The initial proposals are presented in the following three subsections.

## 5.2 Framework for Supplier Relationship Management

Due to time constraint imposed on this thesis study, MoSCoW prioritization technique has been employed to analyse and illustrate the importance hierarchy of solutions recommended by the literature review to tackle the issues presented in supplier diversification targeted challenges category. The key elements of initial proposal concerning SRM framework has been illustrated in Figure 17.

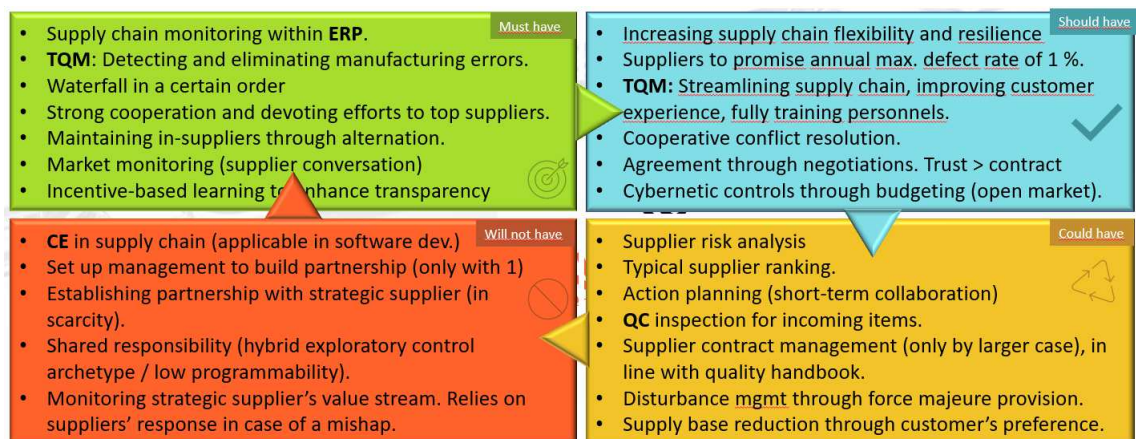


Figure 17 - Initial proposal concerning SRM framework.

Inspecting the MoSCoW prioritization concerning SRM framework as presented in Figure 17, must-have categories are due to the following reasons:

- Regarding Miocevic & Crnjak-Karanovic's (2012) KSRM dimensions, Aventra's supply chain monitoring is enabled by the in-built function within

the ERP systems where PO status turns red in case of delay. Managerial framework implementation is done through market monitoring and conversation with suppliers every few weeks.

- Concerning Toivanen's (2017) supply chain strategy to adapt to volatility, the Senior Partner stated that:

*Some TQM practices are already in effect, such as detecting and eliminating manufacturing errors. Waterfall in a certain order is also currently employed.*

- On the subject of theoretical frameworks featured in (Mantere, 2015), the Senior Partner suggested that strong cooperation with suppliers is a key.
- Considering SRM phase model by Moeller, et al. (2006), the Senior Partner stated the importance of maintaining in-suppliers through alternation.
- Regarding management control systems by Malmi & Brown (2008), the author has observed that incentive-based learning within the alliance to enhance transparency and reciprocal behaviour has already been applied unconsciously through multiple suppliers.

The second hierarchy presented in the MoSCoW prioritization concerning SRM framework in Figure 17, should-have categories are due to the following reasons:

- Within Toivanen's (2017) supply chain strategy to adapt to volatility, the Senior Partner stated that there might be only one supplier with the ability to comply in regard to increasing supply chain flexibility or resilience. Other TQM aspects mentioned such as streamlining supply chain, improving customer experience, and making sure personnels are fully trained would also be beneficial.



- Upon reviewing in-supplier dissolution management through supply base reduction through SRM phase model by Moeller, et al. (2006), the Senior Partner suggests that suppliers should promise an annual maximum defect rate of 1% in dual-interface cards where the RFID module is integrated prior to the contact chip.
- Considering management control systems by Malmi & Brown (2008), the Senior Partner stated the following:
  - *Cooperative conflict resolution within cultural controls is difficult to implement. Through a case example of one open market purchase originating from the far east, the supplier offered a refund, but Aventura had to bear the high shipping cost. When that was rejected, they offered redundant items as a stock clearance method.*
  - *Long-term inter-organizational planning and structure can be incorporated to a customer's contract, but not suppliers. With suppliers, agreement can be achieved through negotiations when there is a solid chemistry. Trust has a higher value than contract, which suggests a lower trust level.*
  - *Cybernetic controls, especially in budgeting is already applied.* The author compares offers received from the open market for RFID products.

The third hierarchy presented in the MoSCoW prioritization concerning SRM framework in Figure 17, could-have categories are due to the following reasons:

- The Senior Partner agrees on maintaining a good relationship with suppliers to a certain extent and through supplier risk analysis.
- While reviewing hybrid exploratory control archetype with low programmability as featured in Mantere's (2015) theoretical frameworks, the Senior Partner agreed that typical supplier ranking could be beneficial

- Considering management control systems by Malmi & Brown (2008), the Senior Partner accepted inter-organizational action planning suggestion through short-term collaboration.
- Regarding Toivanen's (2017) supply chain strategy to adapt to volatility, the Senior Partner stated:

*High faith has been placed on suppliers as there is no QC inspection procedure in place yet for incoming items.*

Some suppliers with lower inclination towards CRM might neglect quality.

- Considering in-supplier dissolution management through supply base reduction employed in SRM phase model by Moeller, et al. (2006), the Senior Partner summarized that quality and service can be enhanced through a supplier-based contract, which could be in line with specified standards found in Aventura Oy's (2022) quality handbook in order to produce a high yield. Considering in-supplier disturbance management, force majeure with legal contracts provision could be implemented. The purpose is to shield parties from liability in the case of a significant unanticipated occurrence. Concerning in-supplier dissolution management through supply base reduction, the author stated that becoming more customer-centric has been observed in one loyal customer where their preference towards a certain thickness of card body has evolved to the standard for that particular RFID card.

The last hierarchy presented in the MoSCoW prioritization concerning SRM framework in Figure 17, will not have categories are due to the following reasons:

- Regarding Toivanen's (2017) supply chain strategy to adapt to volatility, the Senior Partner agreed that CE approach would be more applicable to Aventura's software development but not supply chain process.

- Considering SRM phase model by Moeller, et al. (2006), although set-up management to build partnership has been done with Key Supplier 2 through a strategic sales incentive programme that the author bridged to be established in 2022 but having them as an only supplier partner is not a strategic approach in times of scarcity. Neither is establishing partnership with any single strategic supplier.
- On the subject of hybrid exploratory control archetype with low programmability, as featured in Mantere's (2015) theoretical frameworks, the Senior Partner commented:

*Strong cooperation is key but not shared responsibility. Order still flows constantly to the suppliers even though increased wafer price has been observed. In case of customer's order confirmation delay after initial offer, the suppliers might be the ones bearing possibly increased wafer cost or the cost might be split in half.*

As reported in Section 3.5.3, Aventura bears the cost of defective amount which passed supplier's QC and there is need for recording the amount for accounting purposes. From each batch, the reported amount of defects may be processed as a store credit which could be utilized in the next order.

- Regarding Miocevic & Crnjak-Karanovic's (2012) KSRM dimensions, it has been observed that Aventura seldom monitors the strategic supplier's value stream. It relies on suppliers update information. They are obliged to respond accordingly in case of mishap.

### 5.3 Supply Base Diversification

Similar to how Section 5.2 is reported, MoSCoW prioritization technique has been employed to analyse and illustrate the importance hierarchy of solutions recommended by the literature review to tackle the issues presented in supplier diversification targeted challenges category. The key elements of initial proposal concerning supply base diversification has been illustrated in Figure 18.



Figure 18 – Initial proposal concerning supply base diversification.

Inspecting the MoSCoW prioritization concerning supply base diversification as presented in Figure 18, must-have categories are due to the following reasons:

- Pertaining Cadot, et al.'s (2014) import diversification with quality search, Aventra is most likely to import items of higher quality as it is located in a country with higher income levels, than a country with more trade openness who imports from a larger number of suppliers.
- Regarding Do's (2022) guidelines to alleviate each shortage phase, the Senior Partner stated:

*In pre-disruption phase, risk management practices such as supply chain alignment practice in which ERP systems handle end-to end information flows and monitor the most recent state of various supply chain operations is already in place.*

During and post-disruption phase, as implemented by other companies struggling with semiconductor shortage, increasing buffer stock by alternating system parameters, boosting safety stock levels, expanding purchase sizes, and compromising purchase inventory rotation are definite must-haves. Customers must also be advised to use a similar strategy to assure delivery accuracy during the shortage.

Inspecting the MoSCoW prioritization concerning supply base diversification as presented in Figure 18, should-have categories are due to the following reasons:

- Pertaining to Do's (2022) risk management practices in pre-disruption phase, the Senior Partner deemed employing up to four alternative suppliers for the same component to be a good practice. He further described:

*When it comes to suppliers' contact chip procurement, it all boils down to whose turn it is to receive the reel of unfused contact chips (containing 10 000 pcs) from the OEM. Even when the reservation fee is paid in advance, in general suppliers are against reserving impacted chips because there is a risk of lost currently prospective sales when other customers also demand the same chips, and the items have continuous flow of purchase. Unlike machineries, contact chip cards do not usually have a risk of depreciation and amortization. Customer loyalty is still gained even if longer lead time is imposed as the products are already part of the customer's fundamental offering.*

- The author further described that purchases from open market in order to boost performance is nice to have, although the compatibility must be tested in advance.
- The Senior Partner expressed the needs for frequent follow-ups via active discussions with clients, regular meetings and (daily) conversations with suppliers. He further stressed on the importance of stock value optimization, otherwise the capital would be tied up in the inventory which poses a high risk.

Inspecting the MoSCoW prioritization concerning supply base diversification as presented in Figure 18, could-have categories are due to the following reasons:

- Pertaining to Do's (2022) guidelines to alleviate each shortage phase, the Senior Partner approved the suggestion to utilize alternative components which requires R&D agility to test on alternative materials.
  - During and post-disruption phase, demand management which identifies the customers requiring the items first have been accepted. The author added that in undelivered orders, total purchase value is often prioritized.
- Relating to Mahsa, et al.'s (2019) multinational selection criteria in volatility era by selecting numerous suppliers with varying lead times to provide constant commodity supply, the Senior Partner agreed that purchasing a small batch of hundreds at a higher price seems to be a good practice, but not if MOQ is 1000 pcs. The determining annual purchase should still be made from the most strategical source. He further explained that Aventra has an actively implemented risk prevention measures which is not yet documented, but there is a tendency to choosing suppliers with shorter lead times and higher pricing.

Inspecting the MoSCoW prioritization concerning supply base diversification as presented in Figure 18, will not have categories are due to the following reasons:

- Pertaining to Do's (2022) guidelines to alleviate post-disruption phase, the Senior Partner agreed that additional purchases from local markets is not a good practice because they tend to be Aventra' competitor. Negotiations to deny any postponement or request for improvement will also not help in waver procurement. The author further stated that some suppliers actively use third party communication platforms which lacks documentability even if it has been constantly advised against
- Regarding Swaminathan & Shantikumar's (1999) method of employing the identical number of potential suppliers that Aventra should utilize to satisfy

their demand request in a discreet demand environment, the Senior Partner stated:

*Currently the demand is not quite discreet, hence the price is quite stable for the impacted items. When the market sees supply and demand stability, then the products can be reserved without risking the supplier.*

## 5.4 Delivery Terms Agreement

Similar to how Section 5.1 and 5.2 have been reported, MoSCoW prioritization technique has been employed to analyse and illustrate the importance hierarchy of solutions recommended by the literature review to tackle the issues presented as the lack of delivery agreement within the targeted challenges category. The key elements of initial proposal concerning delivery terms agreement has been illustrated in Figure 19.

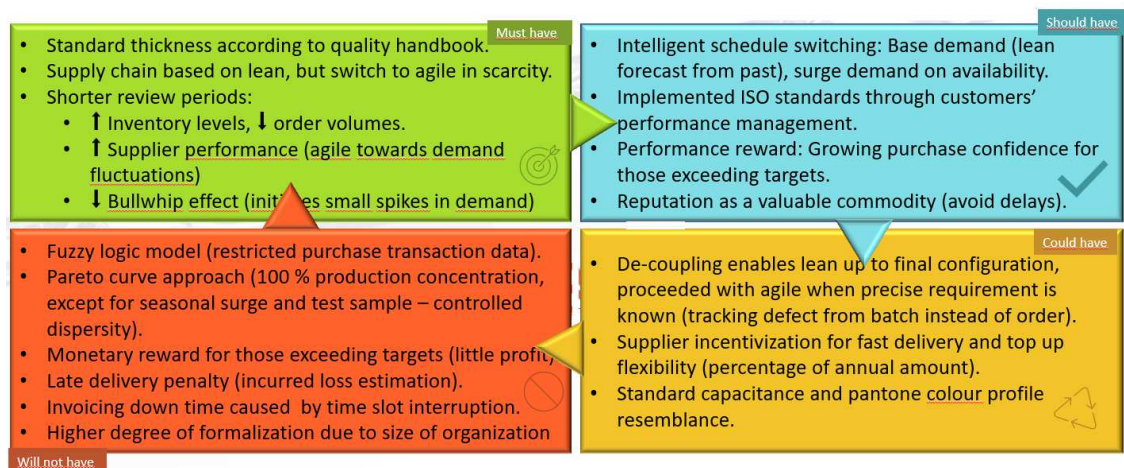


Figure 19 – Initial proposal concerning delivery terms agreement.

Inspecting the MoSCoW prioritization concerning delivery terms agreement as presented in Figure 19, must-have categories are due to the following reasons:

- Concerning logistics service contracts overview by Forslund (2009), the Senior Partner pointed:

*Many customers manage performance with ISO standards, which is already implemented with Aventra's tangible and intangible products.*

As a low-level formalized scenario which enables improvement benefits achievement, the standards have been elaborated in Aventura Oy's (2022) quality handbook concerning standard thickness.

- While assessing Figure 15 – Differences between lean and agile paradigm based on market qualifiers and winners featured in Christopher & Towill's (2001) supply chain strategies and execution model, the Senior Partner commented that Aventura's supply chain is based on lean paradigm but in periods of scarcity, the agile method has been more concentrated on.
- In response to Katok, et al.'s (2008) inventory SLA as coordination mechanisms, the author concluded:
  - Shorter review periods result in great inventory levels and lower order volumes are already in place.
  - Shorter review periods which result in improving supplier performance, since suppliers are able to respond more promptly to demand fluctuations are already in place through agile practices.
  - Supply chain bullwhip effect which initiates small spikes in demand are reduced by shorter review periods.

Inspecting the MoSCoW prioritization concerning delivery terms agreement as presented in Figure 19, should-have categories are due to the following reasons:

- While combining lean and agile paradigms according to Christopher & Towill's, (2001), the separation of base and surge demands model by intelligent schedule switching has been accepted for enhancing supply chain. The base demand the current procurement model which is forecasted from past history through lean procedure. Surge demand is topped up near the market (or rather on availability regardless the cost).



- While assessing Equation 1 - Supply chain total PDP (product delivery process) costs, which specifically summarized that excessive lead-time and cost are waste, the Senior Partner commented that the delay might result in bad reputation and reputation is a valuable commodity.
- Concerning logistics service contracts overview by Forslund (2009), the Senior Partner highlights:

*Many customers manage performance with ISO standards, which is further implemented towards Aventra's tangible and intangible products. Another view from the article is regarding performance reward for those performing above the agreed targets, they will receive a growing purchase confidence for future procurement instead. Monetary reward is not a good strategy due to the little profit left from implementing the model.*

Inspecting the MoSCoW prioritization concerning delivery terms agreement as presented in Figure 19, could-have categories are due to the following reasons:

- While combining lean agile paradigms according to Christopher & Towill (2001), the Senior Partner commented that the de-coupling point is deemed a good practice. De-coupling enables lean up to final configuration, which is then proceeded with agile when the precise customer requirement is known. De-coupling point also enables tracking the total amount of defects from each batch instead of order. The suggested approach has been elaborated in Section 3.5.3.
- Considering incentives and penalties model observed in Forslund (2009), the Senior Partner accepted a contract model which states supplier incentivization for on-time delivery. The reasonable annual amount could be calculated percentagewise from each component, which rewards supplier on ASAP delivery and flexibility to top up if needed.

- Standard capacitance and pantone colour profile resemblance have yet to be defined in more detail within Aventura Oy's (2022) quality handbook to meet the quality managed by the customers' ISO standards.

Inspecting the MoSCoW prioritization concerning delivery terms agreement as presented in Figure 19, will not have categories are due to the following reasons:

- Concerning logistics service contracts overview by Forslund (2009), the author observes that only some hundreds of purchase transactions have been recorded in Aventura's ERP systems so far. Due to the restricted amount of data, there is no benefit in employing fuzzy logic model.
  - The Senior Partner stated that monetary reward is not a good strategy due to the little profit left from implementing the model.
  - The Senior partner further argued that no supplier would agree to a late delivery penalty which includes predetermined sum that the supplier needs to pay with incurred loss estimation.
  - The Senior Partner highlighted the current size of Aventura Oy as elaborated in Section 1.1 upon the remarks which states that larger organizations are anticipated to have a higher degree of formalization. Otherwise, it would be sensible to employ.
- While combining lean and agile paradigms according to Christopher & Towill's, (2001), the Pareto curve approach cannot be implemented to the current manufacturing model because 100 % of Aventura's production is concentrated within one line, except for seasonal surge and test samples when a controlled production dispersity is in effect.
- While assessing Christopher & Towill's (2001) supply chain strategies and execution model, the Senior Partner commented:

*Down time caused by time slot interruption which was originally reserved for a specific task even with ABC in place cannot be invoiced to the customer. Deployment largely depends on the customer's commitment towards the project. Customers make final decisions based on Aventura's viewpoints and Aventura holds on before the installation decision is finalized by the customer's authority figure.*

## 5.5 Summary of The Action Plan Proposal

The initial action plan proposal based on challenges featured in the current state analysis and the conceptual framework was successfully co-created with the Senior Partner due to the Senior Partner's direct role in enabling prospective functions related to procurement process improvements within the ERP system.

The initial proposals surrounding framework for SRM, supply base diversification and delivery terms agreement were presented in this Section. The complete raw field notes from this solution building workshop are documented in Appendix 5.

The following Section 6 comprises feedback validation from the initial action plan proposal covered in this section to improve Aventura's current procurement process.

## **6 Feedback Validation on The Proposed Action Plan Models**

The validation of the co-created initial action plan proposal is documented in Section 6. This section begins with the proposal validation phase overview, afterwards it describes feedback and validations received, alongside adjustments to the initial proposal. Finally, this section wraps up by presenting a summary of the changes made to the initial proposal.

## 6.1 Overview of The Proposal's Validation

The objective of this master's thesis work is to propose actions to improve Aventura's contact chip procurement process during global chip shortage. The feedback and validation on the initial proposal creation stage was carried out with the CEO of Aventura Oy, Jan Sjöblom and the Senior Partner, Timo Markkula, MSc. (Aventura's CEO 2004 – 2021) as the core decision makers of all the organization's processes and implementations.

In order to assist the information flow and support the information gathering credibility for the thesis project, the author presented the topic in its entirety from a general overview of the initial business challenge, the objective, and the outcome. Followed by the applied research plan, analysis of Aventura's current procurement process, procurement process improvement ideas from existing literature and best practices. After a general introduction to the study, the session's theme was introduced, which was the feedback and validation on the initial action plan proposal.

The FG live presentation was initially booked for 45 minutes, but the meeting was unintentionally stretched to 1 hour due to the stronger focus on the leading sections before the initial proposal concerning refurbished supplier coordination practices.

The discussion was then redirected towards process enhancements pertaining to this particular topic. Co-creation included brainstorming, discussions, and evaluations on the proposed ideas. Participants were very much engaged and interested in contributing their ideas and evaluating those of others. During the final stage of the FG live presentation, the participants had the opportunity to discuss in case of overlapping proposals.

The complete raw field notes from the solution building workshop are documented in Appendix 6. The feedback received and adjustments to the initial action plan proposal are presented in the following three subsections.

Summary of the final action plan proposal is documented to complete this section.

## 6.2 Feedback Received and Adjustments to the Initial Action Plan Proposal

Due to timeboxing, MoSCoW prioritization has been implemented in each initial proposal element as documented in Section 5.2, 5.3 and 5.4. The first proposed MosCow prioritization model shown in Figure 17 was initially approved through an email conversation by the Thesis Advisor and later on was accepted by the stakeholders during the feedback and validation presentation with a few suggested changes documented in Section 6.3 and the details in Appendix 6.

As strongly recommended by Metropolia's thesis committee upon the initial and final proposal presentation and in order to yield the possible best outcome from the thesis study, action plan models containing a more concrete plot including the responsible department for action implementation, current status or progress and the estimated total implementation of the task have been devised. Following this explanation, final proposal concerning SRM framework depicted in Figure 20 have been developed from Figure 17, supply base diversification depicted in Figure 21 from Figure 18 and delivery terms agreement Figure 22 from Figure 19.

The following logic is applied while inspecting general action plan proposals covered in Section 6.2.1, 6.2.2 and 6.2.3:

- Procurement holds the most responsibility in supplier coordination category due to direct contact with the providers.
- Weighing the importance of must-have parameters, the status of each action plan is either functioning, under development or internalized. They are either already implemented and already a part of JIT procurement process advantages, undergoing a continuous development or have a more

concretely discussed timeline when the parameters will certainly be implemented.

- The should-have parameters introduce implementation actions within the next importance hierarchy. Statuses are either internalized, next in progress, under development or already partially implemented. Estimated implementation timelines are rather not as concrete compared to the must-have parameters because the covered issues are less pressing.
- The could-have parameters consist of action plans with the least importance hierarchy. Statuses are typically next progress, partially or somewhat implemented, low importance level or internalized without having been implemented. Estimated implementation timelines are rather vague compared to the higher hierarchy parameters because the tasks are generally not reserved and are nice-to-haves when time permits.
- The will not have parameters featured in Figure 17, Figure 18 and Figure 19 have been taken out of each action plan model as there is no need for implementation. Estimated implementation timelines stretch to the unforeseeable future compared to the other two parameters such as later, more later, and if needed.

### 6.2.1 Framework for Supplier Relationship Management

Final proposal concerning SRM framework depicted in Figure 20 have been developed from Figure 17.

		Responsible department	Status	Estimated implementation
Must have	1) Supply chain monitoring within ERP.	1) Procurement	1) Functioning	1) ✓
	2) TQM: Detecting and eliminating manufacturing errors.	2) ERP developer	2) Under development	2) FW2023
	3) Waterfall in a certain order	3) Procurement and production	3) Implemented	3) ✓
	4) Strong cooperation and devoting efforts to top suppliers.	4) Procurement	4) Internalized	4) Continuous
	5) Maintaining in-suppliers through alternation.	5) Procurement	5) Internalized	5) Continuous
	6) Market monitoring (supplier conversation)	6) Procurement and stakeholders	6) Every few weeks	6) Continuous
Should have	7) Increasing supply chain flexibility and resilience	7) Procurement	7) Internalized	7) Continuous
	8) Suppliers to promise annual max. defect rate of 1 %.	8) Production	8) Next progress	8) FW2023
	9) TQM: Streamlining supply chain, improving customer experience, fully training personnels.	9) Stakeholders	9) Under development	9) Continuous
	10) Cooperative conflict resolution.	10) Procurement	10) Next progress	10) FW2023
	11) Agreement through negotiations. Trust > contract	11) Procurement	11) Next progress	11) More later
	12) Cybernetic controls through budgeting (open market).	12) Procurement	12) Partially implemented	12) Continuous
Could have	14) Supplier risk analysis	14) Procurement	14) Next progress	14) Later
	15) Typical supplier ranking.	15) Procurement and ERP dev.	15) Partially implemented	15) More later
	16) Action planning (short-term collaboration)	16) Procurement	16) Some implemented	16) If needed
	17) QC inspection for incoming items.	17) Procurement and production	17) Implemented	17) Continuous
	18) Supplier contract management (only by larger case), in line with quality handbook.	18) Stakeholders and procurement	18) Implemented	18) If needed
	19) Disturbance management through force majeure provision.	19) Procurement and stakeholders	19) Implemented	19) Later
	20) Supply base reduction through customer's preference.	20) Sales and procurement	20) Next progress	20) If needed
			20) Part implement	

Figure 20 – Action plan proposal concerning SRM framework, derived from Figure 17

Following the logic explained in the opening Section 6.2, some exceptions that are worth describing from the action plan proposal concerning SRM framework in Figure 20 are:

- Under the must-have parameters:
  - TQM of detecting and eliminating manufacturing errors largely falls under ERP developer's responsibility area. The design for implementation has been discussed prior to the feedback and validation session and it is to be implemented in fall-winter 2023.
  - Waterfall in a certain order also falls under production's responsibility area as they play a crucial role within the supply chain.
  - Market monitoring through supplier conversations every few weeks is also done by the stakeholders.
- Under the should-have parameters:

- Defect rate is measured within the production for each rejected preform. The defect rate measurement within the ERP system was discussed to be in progress and will be launched in fall-winter 2023.
- Continuous total quality management of streamlining supply chain, improving customer experience and fully training personnels fall largely under the stakeholders' responsibility.
- Under the could-have parameters:
  - In the event of typical supplier ranking implementation within the ERP systems, the action will be ERP developer's responsibility.
  - Stakeholders have the decision power regarding supplier contract management which is in line with the already functioning quality handbook and disturbance management through force majeure provision. Procurement holds the implementation responsibility.
  - Sales holds the responsibility in supply base reduction through customers' preference to eliminate incompatible items.
  - QC inspection for incoming items is already continuously implemented. The inspection is typically conducted under a tight schedule because incoming tailorable items are to be passed directly to the production.

### 6.2.2 Supply Base Diversification

Final proposal concerning supply base diversification depicted in Figure 21 have been developed from Figure 18.



		Responsible department	Status	Estimated implementation
Must have	1) Import diversification with quality search	1) Procurement 2) ERP developer 3) Departments: a) Procurement and ERP b) Procurement c) Procurement and sales d) Sales	1) Internalized 2) Functional 3) Status: a) Next prog. b) Next prog. c) In progress d) Next prog.	1) Continuous 2) ✓ 3) Schedule: a) FW23 b) FW23 c) Cont. d) FW23
	2) Supply chain alignment within ERP to monitor SCO			
	3) Increasing buffer stock by: a) Alternating system parameters b) Boosting safety stock levels and purchase sizes c) Compromising purchase inventory rotation d) Advising customers to adopt similar strategy			
Should have	4) Employing < 4 alternative suppliers for the same component.	4) Procurement 5) Procurement and production 6) Procurement, sales and stakeholders 7) Procurement and ERP developer	4) In progress 5) Internalized 6) Implemented 7) Next progress	4) Continuous 5) Continuous 6) Continuous 7) More later
	5) Open market purchase to boost performance (with compatibility testing in advance).			
	6) Frequent follow-ups with clients and suppliers. 7) Stock value optimization to lessen the risk of capital being tied up in inventory.			
Could have	8) Utilizing alternative components (requires R&D agility to test on alternative materials).	8) Procurement and R&D 9) Sales and projects 10) Procurement 11) Procurement	8) Next progress 9) Internalized 10) Low priority 11) Internalized	8) Later 9) Continuous 10) Later 11) Eventual
	9) Demand management: Identify which customers require the items first (contract and value prioritized)			
	10) Numerous suppliers with varying lead times for a constant supply. 11) Risk prevention measures: Tendency to choose suppliers with shorter lead times and higher cost.			

Figure 21 - Action plan proposal concerning supply base diversification, derived from Figure 18.

Following the logic explained in the opening Section 6.2, some exceptions that are worth describing from the action plan proposal concerning SRM framework in Figure 21 are:

- Under the must-have parameters:
  - The responsibility to align supply chain within ERP to monitor SCO and alternating system parameters fall under the ERP developer's responsibility. Further system parameter alternation after the function has been created falls under the procurement's responsibility.
  - Sales are responsible for compromising purchase inventory rotation and advising customers to adopt similar agility strategy to increase the buffer stock.

- Under the should-have parameters:
  - Compatibility testing from open market purchase to boost performance falls under production’s responsibility.
  - Sales and stakeholders have the responsibility to hold frequent follow-ups with clients and suppliers.
  - Stock value optimization model set-up falls under the ERP developer’s responsibility.
- Under the could-have parameters:
  - R&D has the responsibility to test on alternative components which has been collected by the procurement.

### 6.2.3 Delivery Terms Agreement

Final proposal concerning delivery terms agreement depicted in Figure 22 have been developed from Figure 19.

		Responsible department	Status	Estimated implementation
Must have	1) Standard thickness according to quality handbook. 2) Supply chain based on lean, but switch to agile in scarcity. 3) Shorter review periods: <ul style="list-style-type: none"> <li>• ↑ Inventory levels, ↓ order volumes.</li> <li>• ↑ Supplier performance (agile towards demand fluctuations)</li> <li>• ↓ Bullwhip effect (initiates small spikes in demand)</li> </ul>	1) Procurement and suppliers 2) Procurement and sales 3) Procurement	1) Implemented 2) Internalized 3) Partly implemented	1) Continuous 2) Continuous 3) FW2023
Should have	4) Intelligent schedule switching: Base demand (lean forecast from past), surge demand on availability. 5) Implemented ISO standards through customers’ performance management. 6) Performance reward: Growing purchase confidence for those exceeding targets. 7) Reputation as a valuable commodity, suppliers to avoid delays.	4) Procurement and ERP dev. 5) Stakeholders, sales and procurement 6) Procurement and sales 7) Procurement and sales	4) Next progress 5) Implemented 6) Functional 7) Internalized	4) FW2023 5) Continuous 6) Continuous 7) Continuous
Could have	8) De-coupling enables lean up to final configuration, proceeded with agile when precise requirement is known (tracking defect from batch instead of order). 9) Supplier incentivization for fast delivery and top up flexibility (percentage of annual amount). 10) Standard capacitance and pantone colour profile resemblance.	8) ERP developer and production 9) Stakeholders and procurement 10) Procurement and stakeholders	8) Next progress 9) Low priority 10) Low priority	8) Later 9) If needed 10) If needed

Figure 22 - Action plan proposal concerning delivery agreement, derived from Figure 19

Following the logic explained in the opening Section 6.2, some exceptions that are worth describing from the action plan proposal concerning SRM framework in Figure 22 are:

- Under the must-have parameters:
  - Suppliers have the responsibility in meeting standard thickness that has been informed during procurement process.
  - Sales should be able to instinctively distinguish when would be the right time to switch to agile in times of scarcity and communicate solutions to customers.
- Under the should-have parameters:
  - ERP developer has the ability to design the function for intelligent schedule switching, but it is up to procurement to apply the functions in recurring tasks.
  - Sales play a big role in implementing ISO standards through customers' performance management through stakeholder briefing. Furthermore, observed exceeded target performance and reputation upkeep also befall on sales.
- Under the could-have parameters:
  - ERP developer has the ability to design the function for de-coupling up to the final configuration, but it is up to production to apply the functions in recurring tasks.
  - Stakeholders hold the decision for suppliers' annual incentivization from the procurement's gathered data. Stakeholders also could decide on the implementation of standard capacitance and pantone profile resemblance

in the quality handbook, from then procurement carries the QC for incoming goods.

### 6.3 Summary of The Final Action Plan Proposal

The stakeholders were in general very supportive and the entire thesis study along with the initial proposals were validated with excellent feedback. As elaborated in Section 6.2, MoSCoW prioritization has been converted into action plan models containing a more concrete plot including the responsible department for action implementation, current status or progress and the estimated total implementation of the tasks.

Figure 23 summarized the remarks gathered from the stakeholders during the feedback and validation FG live presentation, which adjusts the presented initial proposals.

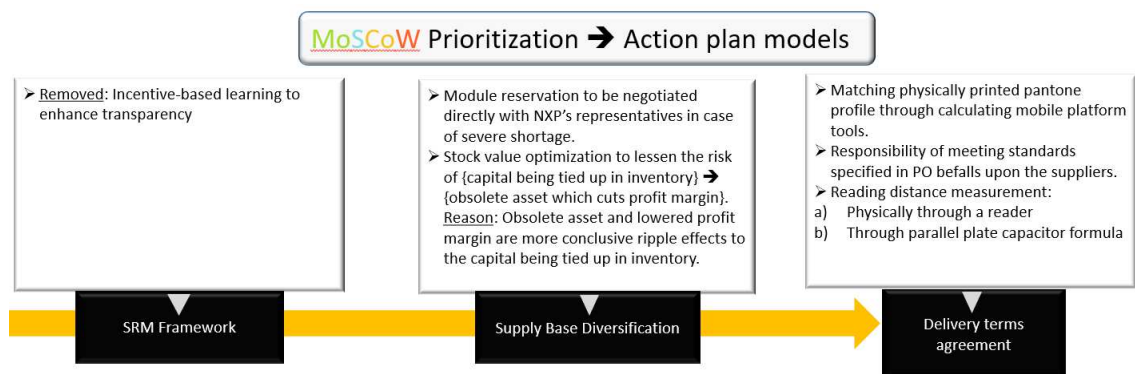


Figure 23 – Summary of the adjustments made to the initial proposal.

Adjustments showcased in Figure 23 are:

- 1) SRM framework: Incentive-based learning within the alliance to enhance transparency and reciprocal behaviour has been removed from the action plan proposal. Although unconsciously applied through multiple suppliers, but it is not deemed concrete enough for documentation purposes.

## 2) Supply base diversification:

- Upon assessing the first should-have parameter to employ up to 4 alternative suppliers for the same component as suggested by Do's (2022) guidelines to alleviate the pre-disruption phase of the shortage. The CEO pointed out:

*The chips come from NXP with four wafer fabrication facilities found in Austin, Texas, Arizona, the Netherlands, and Singapore (NXP Semiconductors, 2023). The CEO further suggested that module reservation might possibly be negotiated through NXP's representatives with whom Aventura is in direct contact with.*

- As pointed out by the Senior Partner, the last should-have proposal and Section 3.4.1 Manageable with a Smaller Storage Space have been rephrased to:

*Stock value optimization to lessen the risk of obsolete asset which cuts profit margin.*

Obsolete asset and lowered profit margin are more conclusive ripple effects to the capital being tied up in inventory.

## 3) Delivery terms agreement:

- Upon reviewing the last could-have proposal regarding "the standard capacitance and pantone colour profile resemblance have yet to be defined in more detail" as initially recommended by the Senior Partner in Appendix 5, the respondent hinted that Aventura Oy's (2022) quality handbook could be improved based on the proposal but at the same time pondered on the implementation practices. The author suggested pantone colour matching tools commercially available on standard mobile platforms. Bearing in mind that the sample has to already be on a physically printed format, hence the application could suggest results

based on the closest pantone colour bridge coated profile and calculate the percentage resemblance between the recommended values to the physical sample.

- The stakeholders suggest that the responsibility of meeting the standards specified in each PO befalls upon the supplier. According to Aventra's Quality handbook v1.6 (2022), in case the quality deviations are not up to Aventra's and ultimately the customer's predetermined standards, the customers may negotiate measures depending on the deviation's severity.
- The reading distance measurement standard has to yet be defined as initially recommended by the Senior Partner in Appendix 5:
  - In a parallel-plate capacitor, the reading distance can be calculated according to Equation 3.

Equation 2 - Distance measurement of capacitance

$$d = \frac{\varepsilon_0 \varepsilon_r A}{C}$$

where:

$d$  indicates the distance between plates in meters.

$\varepsilon_0$  marks the electric constant ( $8,85 \times 10^{-12} \frac{F}{m}$ )

$\varepsilon_r$  indicates the dielectric constant of materials between plates.

$\varepsilon_r=1$  for air, where the testing environment always is for Aventra's use case.

$A$  marks the overlapping area of the two plates in sqm.

$C$  defines the capacitance in Farads (standard value 17pF or 70pF in RFID modules).

(Järvinen, et al., 2019)

- In practice, the physical distance evaluation has been performed upon obtaining RFID articles to verify the agreed specification has been met.

The seventh and the final section of the study concludes the thesis work by covering the executive summary, recommending potential implementation plan after the study based on the final proposals and the other two categorized challenges uncovered by the study from Section 3.6 and self-evaluation on the thesis project's credibility.

## **7 Summary and Conclusions**

This section concludes the thesis study with an executive summary, recommendations for potential implementation plan, self-evaluation of the thesis project credibility and its findings, and lastly the closing words. Conclusion plays an important role of the thesis study as it is oftentimes the only section that is read by the stakeholders besides the abstract and introduction as a part of proposal (Holappa, 2023).

### **7.1 Executive Summary**

The objective of this master's thesis work is to propose actions to improve Aventura's contact chip procurement process during global chip shortage. The outcome of this thesis is a list of proposed partial improvement plans including strategical guidelines and action steps which could be used to smooth out the procurement process of semiconductor products. The impact of the globally identified problem of a chip shortage is seen primarily in procurement, production, and sales department. Under perfect circumstances, a JIT inventory system would be the desired management strategy. Consequentially, the supply

shortage has made it generally impossible to achieve a high level of customer satisfaction due to longer production time. The entire smartcard industry is suffering due to this backlash. Secondly the shortage also impacts the entire operation, as development projects have a potential gravitation to revolve around the availability of materials and technology used.

Applied action research was selected as the research design combined with qualitative methods by means of method triangulation. Qualitative research approach is best suited for this study because the specific phenomenon is considerably new. The thesis study includes four stages. The first stage is the current state analysis identifying advantages and challenges of the procurement process. The second stage is the conceptual framework, featuring literature review from available best practices to seek improvement suggestions to the challenges encountered in the first stage. The third stage is the co-created initial action plan proposal towards the stakeholder by utilizing findings from the first and the second stage to improve the current procurement process. The fourth as the final stage is the validation of the initially proposed procurement action plan by gathering feedback from the stakeholders which generates the outcome of this thesis study, the final action plan proposal to improve procurement process.

The current state analysis was performed by organizing IDI interview sessions to different stakeholders involved in Aventura's supply chain process and its development, distributing supply chain themed questionnaires to chip product suppliers, and retrieving lead time data from each chip products suffering from the worst impact from the ERP logs. The findings were categorized into three subgroups of challenges to facilitate a more targeted literature search for improvement ideas. The first challenge category is related to the currently imperfect forecast based on annual consumption level. The second category concerns how the suppliers are currently coordinated, high dependency implicated, and the lack of systematic SLA follow-up. The third category is related to stock and lead time reliability surrounding unrecorded amount on rejected preforms from each production log and MTO orders causing some



delays. The literature analysis was based on current state challenges categories. The conceptual framework contains existing knowledge and best practises aimed to eliminate the identified key challenges.

The initial proposal creation stage was carried out as a live workshop session with the Senior Partner due to the respondent's direct role in enabling prospective functions related to procurement process improvements within the ERP system. The author actively participated in the solution building workshop for the initial proposal due to her responsibility in areas covered such as sales, procurement, and supply chain. In order to steer the focus due to the limited time available for the solution building workshop, a copy of the current state analysis and the conceptual framework along with the reference list was sent to the Senior Partner as a suggested pre-reading material some days prior to the session. All the findings were divided into three categories following the same logic as the current state analysis to tackle the challenges utilizing solutions found on literature review to find the solutions which would best fit the organization.

Due to time constraint imposed on this thesis study, MoSCoW prioritization technique has been initially employed to analyse and illustrate the importance hierarchy of solutions recommended by the literature review to tackle the three identified challenge categories.

Within the SRM framework category, a total of seven must-have action plans such as supply chain monitoring within ERP, TQM by detecting and eliminating manufacturing errors, waterfall in a certain order, strengthening cooperation and devoting efforts to top suppliers, maintaining in-suppliers through alternation, market monitoring through supplier conversation, and incentive-based learning to enhance transparency were initially proposed.

Within the supply base diversification category, a total of three must-have action plans such as import diversification with quality search, supply chain alignment within ERP systems to monitor SCO and increasing buffer stock were initially

proposed. Underneath the buffer stock increasing initial action plan proposal, four sub-action plans were suggested such as alternating system parameters, boosting safety stock levels and purchase sizes, compromising purchase inventory rotation, and advising customers to adopt similar strategy.

Within the final category, initial proposal concerning delivery terms agreement, three action plans such as emphasizing standard thickness according to the quality handbook; employing supply chain management that is based on lean, which switches to agile during period of scarcity and implementing shorter review periods were initially proposed. Underneath the shorter review period initial action plan proposal, three sub-action plans were suggested such as increasing inventory levels and lowering order volumes; supplier performance improvement through agile practices to respond promptly to demand fluctuations; and reducing supply chain bullwhip effect which initiates small spikes in demand.

The initial action plan proposals were validated by Aventura's operative decision makers, the CEO, and the Senior Partner through FG live presentation. In order to assist the information flow and support the information gathering credibility for the thesis project, the author presented the topic in its entirety from a general overview of the initial business challenge, the objective, and the outcome. Followed by the applied research plan, analysis of Aventura's current procurement process, procurement process improvement ideas from existing literature and best practices. After a general introduction to the study, the co-created initial recommendations were presented, which was further evaluated by the stakeholders. Participants were very much engaged and interested in contributing their ideas and evaluating those of others. The first category of SRM framework was approved after slight modification, a couple of points were added on the supply base diversification and three points were added to the delivery terms agreement proposal, which sums up as the final action plan proposal.

The final recommendations provide a comprehensive set of actions to improve the contact chip procurement process for Aventura Oy when partially implemented. Implementing the action plans demand a collaborative effort of departments with both direct and indirect influence towards the supply chain. At the end of the day all proposed elements are targeted to boost sales revenue by providing Aventura Oy solutions to cope with the persisting global semiconductor shortage.

## 7.2 Recommendation for Potential Implementation Plan

The outcome of this thesis is a list of proposed partial improvement plans including strategical guidelines and action steps which are pivotal to smooth out the procurement process of semiconductor products. This subsection identifies concrete practical next step recommendations.

High priority action plans can be implemented through the following measures:

- Under SRM framework, procurement must ensure that supply chain monitoring within *taloushallinto* is fully functioning and maintaining waterfall in the designated order is performed together with production. Procurement must continuously maintain strong cooperation and devoting efforts to top suppliers while alternating the in-suppliers. To avoid real stock volume surprise during annual inventory period, the defect rate from each rejected preform within production log was discussed to be in progress and will be launched in fall-winter 2023.
- Concerning supply base diversification, procurement must continuously diversify import through quality search, and together with sales in mind the buffer stock must be increased by compromising purchase inventory rotation. The ERP developer must maintain the functioning supply chain alignment within *taloushallinto* to monitor SCO. By the next fall-winter 2023, increasing the buffer stock must be done as collaborative effort between the procurement and ERP developer by alternating system parameters, procurement must also boost safety stock levels and purchase sizes by then

and sales must advise customers to adopt similar strategy. Utilizing alternative components which requires R&D agility to test on alternative materials is also deemed important by the author.

- Pertaining to delivery terms agreement, suppliers have the responsibility in meeting standard thickness that has been informed during procurement process, and it is the procurement's responsibility to ensure that the standard is always met. Sales must be able to instinctively distinguish when would be the right time to switch to agile in times of scarcity and communicate solutions to customers. Procurement must fully employ shorter review periods by fall-winter 2023 by increasing inventory levels and lowering volumes during each purchase order, improving supplier performance and enable them to respond more promptly to demand fluctuations, and reducing supply chain bullwhip effect which initiates small spikes in demand.

Aside the thesis scope, one feature that is currently missing from *taloushallinto* is the user's autonomy to restrict and view only the dimensions beneficial to their department's tasks. Currently users can view all historical transaction data and are able to manipulate all open transaction feed, inventory, and CRM data. Although upon reporting to the Senior Partner, the required accessibility to some certain features can be implemented fast if deemed necessary.

This thesis officially paves way for the company's potential next thesis topic from the other challenges categorized into insufficient forecast data, and stock availability and lead time.

### 7.3 Self-Evaluation of Thesis Project Credibility

The business challenge that prompted the author to write this master's thesis work is the globally identified problem of a chip shortage and how it impacts PKI card manufacturers. The objective to propose procurement actions to improve Aventura's contact chip procurement process is based on the business problem and to these days still remain current, realistic, and achievable, although it has

been slightly changed over time. The findings of this study were validated by the stakeholders of Aventura Oy, thus the objective of the study has been achieved according to plan.

Enough time was spared to conduct a proper CSA, encompassing IDI live interviews with Senior Partner and Management Role 1, gathered lead time from the ERP systems, and the sales representatives' questionnaire yielded 41% response rate. Time constraint also enables the author to practice time management through leagile method even in matters related to her studies. The mentorship given by the thesis advisors have been valuable and helpful at breaking down the project into achievable milestone and setting realistic deadlines for each portion. Although on the other hand the pressing project time constraint only allows for a more tightly limited scope which requires no major piloting.

As the Senior Partner previously highlighted, it would be sensible and even anticipated to employ a higher degree of formalization as the size of organization becomes larger. Due to the current number of employees, it was observed that available supply chain literature tends to solve issues aimed at larger organizations.

The author of this study is directly involved in sales, procurement, customers' artwork processing, account payables and receivables, logistics, license subscription renewal and on-demand card production. These responsibility areas are directly impacted by the semiconductor shortage and the recommended action plans would ultimately benefit her professional life as well as the organization. The thesis study has honed the author's skills in negotiating with stakeholders, team members, and most importantly public speaking at a larger audience under evaluation. Team negotiation can be improved by defining clear objectives, timeline, and outcome from the beginning, establishing a common ground, active listening skills, regular effective communication and avoiding criticism. Whereas public speaking skills can be improved by rigorous

rehearsal, employing audience-oriented and engagement approach, refining visual aids and visualizing goals.

The study is evaluated in the following subsections by its validity and reliability, trustworthiness and credibility, and transferability and relevance.

### 7.3.1 Validity and Reliability

To ensure reliability, applied action research was selected as the research design combined with qualitative methods by means of method triangulation. Different sources from a variety of role, academic background, and phenomenon's comprehension, combined with views from multiple external informants, paired with tangible data summarized as conceptual framework containing existing knowledge grounding logic based on previous studies and research. In order to set the focus to the topic at hand, pre-reading materials were sent to each respondent some days prior to the session and in order to ensure its reliability, a compiled report of raw field notes have been sent around 3 days after each session.

As previously mentioned in Section 2.3, an interviewer must be careful when using leading questions, because they may be used to discreetly guide a respondent towards a desired direction. Thus, may risk the credibility of the research if the answered are influenced by the interview process. As a thesis study researcher, the author's role in the interview was as a non-opinionated, probing observant. Therefore, leading questions and themes were avoided to ensure the ethical standard of the research. (Kananen, 2013, pp. 117-119)

Due to time constraint imposed on the thesis study, the validation was done by gathering feedback to the co-created initial action plan proposal from the stakeholders. If time permits, then an actual test to the action plan model via piloting, simulation, trial, model, mock up or partial implementation would certainly be of the author's interest.

### 7.3.2 Trustworthiness and Credibility

When given the option, the author chose to conduct the CSA part of the study prior to the conceptual framework because the solution to the current challenges would be found through the gathered data. The CSA data was gathered through multiple qualitative methods such as live interviews, logs, and supplier questionnaire through multiple informants. All the three methods of conducting CSA were done at different times and combining analytical inputs from smartcard industry's best experts.

Each interview sessions produce raw field notes, which are captured in the appendices of this study. Each interview session was conducted in Finnish to properly convey the respondents' insights. To ensure credibility, the raw field notes translated to English have been delivered to each respondent 3 days after each session. The respondents' words have been quoted as to not alter the interpretation.

At the end of final thesis presentation towards the thesis committee and fellow Metropolia students, the author's thesis advisor, Dr Thomas Rohweder commented that the project is rich in substance. Thus, the visual load in the slides was advised to be minimized, although simultaneously it provides a strong credibility.

### 7.3.3 Transferability and Relevance

The thesis study possesses a high rate of transferability as semiconductor shortage remains a critical issue affecting industries globally. As discussed in Section 1.2, some car manufacturers predict that the normalization would take some time in 2025 and the impact might still be felt within the next two decades. To these days, the challenges caused by semiconductor shortage such as supply chain disruptions, production delays, increased costs and sales confidence are still felt. The main objective of this thesis is to provide Aventura Oy solutions to cope with semiconductor challenge, although the findings might

also be relevant to other PKI smartcard manufacturers dealing with similar issues.

The study's proposal offers a high degree of relevance because the potential solutions are recommended through practical insights, and it offers concentrated action plan steps, along with responsible departments and implementation timeline. The study provides methods to secure a stable supply of contact chips to ensure uninterrupted production cycle. Through the RFID and contact chip questionnaire results shown in Appendix 3, extensive product offering has been discovered from RFID suppliers who also provide contact chip with higher tendency for scarcity. As a result, one of the samples from an out-supplier is currently being tested at Aventra's production site for applet embedding compatibility.

#### 7.4 Closing Words

Attaining the thesis objective was very rewarding, as it resulted in several practical action plan proposals to mitigate the effects of semiconductor shortage. If implemented through collaborative effort, the recommended policies will factor in enhancing the supply chain's resilience and the semiconductor ecosystem's sustainability, which fuels the organization's technological advancement and long-term economic prosperity.

As a closing statement, the author would like to quote Sir Isaac Newton, 1675:

*If I have seen further, it is by standing on the shoulder of giants.*

This quote highlights the importance of acknowledging the contributors who have paved the way and on whose shoulders the researchers stand on. Furthermore, it emphasizes the significance of collaboration, as no one can achieve excellence alone without benefitting from the collective knowledge and experience of others.



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## Appendices

### Data 1 Collection: Structured IDI Interview Questions to the Senior Partner

- 1) Would you give consent that your title at Aventra Oy would be displayed on the thesis work along with name, or should the quotes gathered be documented anonymously as Stakeholder N? The answers gathered would greatly benefit the author's Master thesis current state analysis and could further be implemented in her professional work.
  
- 2) Offset printing process has been mapped out in Aventra's quality handbook Section 5, but the current procurement or supply chain process has not yet been properly mapped out and documented. According to the author's analysis, the current procurement process for contact chip products can be mapped as follows, do you agree or is there any correction?

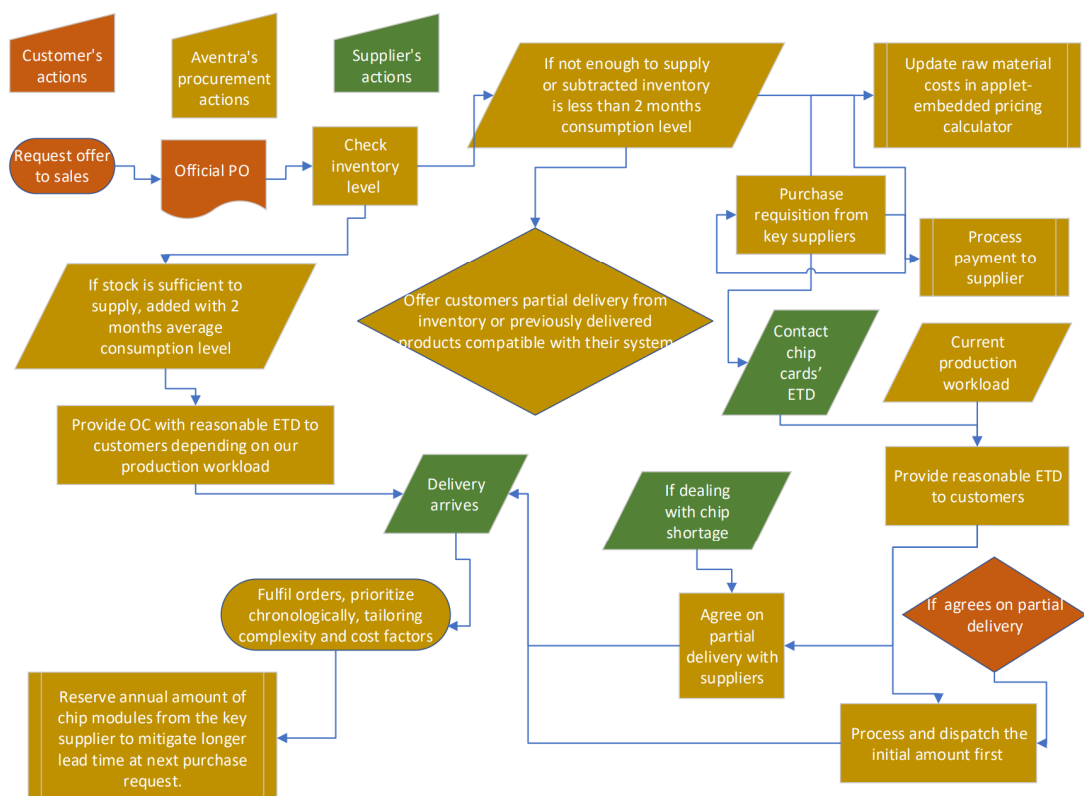


Figure 24 – Proposed procurement process map

- 3) Referring to subcontractors' printing quality described in quality handbook Section 5.4., what are the criteria why some long-term key suppliers of chip products were selected?
  
- 4) What were the initial reasons why the client company decided that NXP's JCOP chips were the most suitable solution for embedding MyEID cards instead of options from other OEMs? Were any of the following Java applet embeddable contact chips ever considered or tested:
  - a. Siemens Semiconductor IC (integrated circuit) SLE 4432 / SLE 4442 / SLE 5528
  - b. Integrated Silicon Solution Inc. ISSI 4442 / ISSI 4428 / ISSI24C02 / ISSI24C128 / ISSI24C16 / ISSI24C64 / ISSI4442 / SLE5528 / SLE5542
  - c. ATMEL AT24C01 / AT24C02 / AT24C08 / AT24C16 / AT24C64 / AT5577
  - d. Fudan FM4442
  
- 5) The current protocol is to manually provide the ERP system a 2-months average consumption level to enable low stock level alert before processing a PO. Would the client company benefit from a polished calculation model based on existing literature analysis?
  
- 6) Here are some of the author's presumptive summary of procurement process advantages and improvement points. Do you agree or disagree with some points and are there more points to add?

Advantages	Challenges
(+) Improve cash flow, as cash is not tied up in inventory	(-) Global chip shortage disrupts supply chain
(+) Smaller storage required	(-) Time pressure
(+) All inventory products are still on-demand	(-) High supplier dependence

Thank you for your time and patience.

## Suomenkielinen käännös: Data 1 keräily: Strukturoidut IDI-haastattelukysymykset Seniori Partnerille

- 1) Antaisitteko suostumuksen siihen, että työnimikkeenne Aventra Oy:ssä näytettäisiin opinnäytetyössä nimenne kanssa, tai dokumentoidaanko lainauksia anonyymisti Sidosryhmä N:nä? Kerätyt vastaukset hyödyttäisivät suuresti kirjoittajan pro gradu -työn nykytilan analyysiin ja niitä voitaisiin soveltaa jatkossakin hänen ammatillisessa työssään.
- 2) Offset-painoprosessi on kartoitettu Aventran laatukäsikirjan luvussa 5, mutta nykyistä hankinta- tai toimitusketjuprosessia ei ole vielä virallisesti kartoitettu tai dokumentoitu. Kirjoittajan analyysin mukaan kontaktisirutuotteiden nykyinen hankintaprosessi voidaan kartoittaa seuraavasti, oletteko samaa mieltä tai onko lisättävää tai korjattavaa?

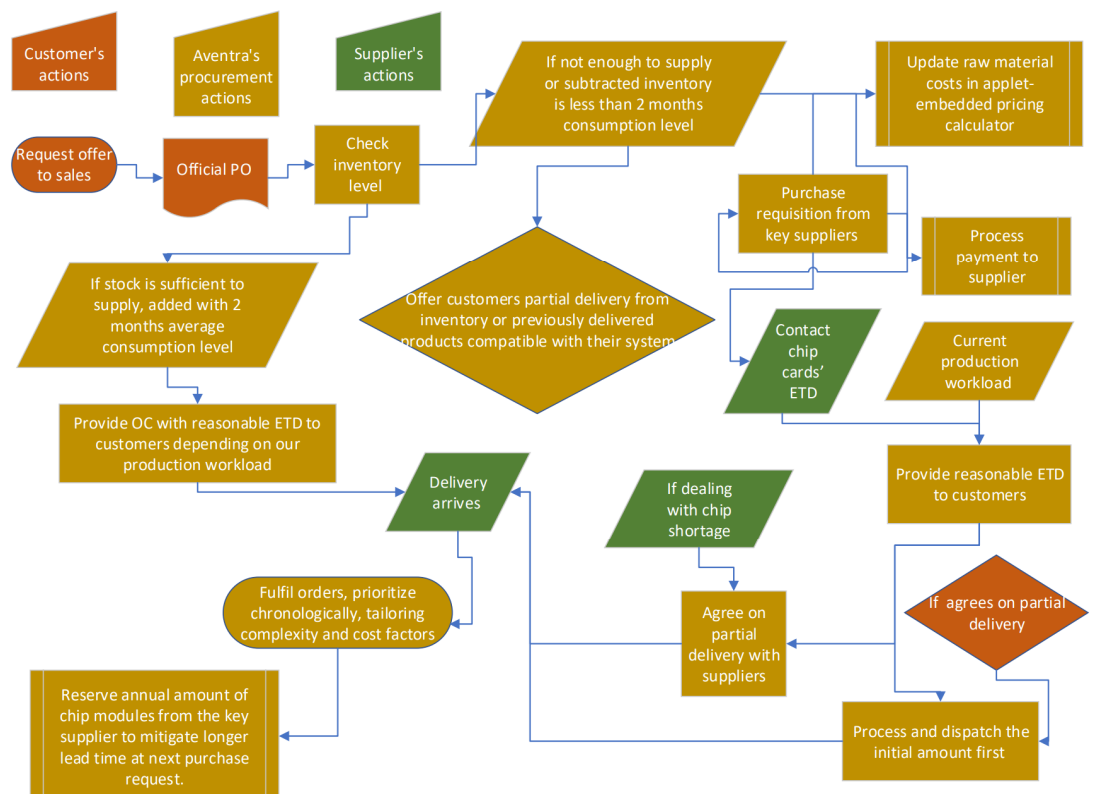


Figure 25 - Ehdotettu hankintaprosessin kaavio



- 3) Viitaten laatukäsikirjan kohdassa 5.4, alihankkijoiden painolaatuun, mitkä ovat kriteerit, joiden perusteella pitkäsuhteiset sirukorttitoimittajat ovat valittu?
- 4) Mitkä olivat alkuperäisiä syitä, miksi Aventura päätti, että NXP:n JCOP-siruja ovat sopivinta ratkaisua MyEID-korttien valmistamiseen muiden OEM-valmistajien vaihtoehtojen sijaan? Onko jokin seuraavista Java kontaktisirukortteja koskaan harkittu tai testattu:
- Siemens Semiconductor IC (integroitu virtapiiri) SLE 4432 / SLE 4442 / SLE 5528
  - Integrated Silicon Solution Inc. ISSI 4442 / ISSI 4428 / ISSI24C02 / ISSI24C128 / ISSI24C16 / ISSI24C64 / ISSI4442 / SLE5528 / SLE5542
  - ATMEL AT24C01 / AT24C02 / AT24C08 / AT24C16 / AT24C64 / AT5577
  - Fudan FM4442
- 5) Nykyisen protokollan mukaisesti, hankinnan va staava syöttää tuotekohtaisesti kahden kuukauden keskimääräisen kulutustaso *taloushallinto* -järjestelmälle, jotta saadaan varoitus alhaisesta varastotasosta ennen tilauksen käsittelyä. Hyötyisikö asiakasyritys olemassa olevaan kirjallisuusanalyysiin perustuvaa hiottua laskentamallia?
- 6) Tässä on joitain kirjoittajan oletettuja yhteenvetoja hankintaprosessin vahvuuksista ja parannuskohtista. Oletko samaa vai eri mieltä joistakin kohdista ja onko vielä lisättävää?

Vahvuudet	Parannuskohtia
(+) Parantaa kassavirtaa, koska käteistä ei ole sidottu varastoon.	(-) Maailmanlaajuinen sirupula häiritsee hankintaa
(+) Edellyttää pienempää varastotilaa	(-) Aikapaine
(+) Kaikki varastotuotteilla on edelleen korkea kysyntää	(-) Suuri riippuvuus toimittajista

Kiitos ajastanne ja harkinnastanne.

**Field Notes: Current State Analysis Interview with the Senior Partner**

<b>Interview participant</b>	Timo Markkula, MSc., Senior partner (Aventra Oy's CEO 2004 – 2021)
<b>Place</b>	Aventra's meeting room
<b>Time</b>	17.01.2023, 13:30 – 15:30
<b>Duration</b>	2 hours
<b>Language</b>	Finnish
<b>Setting</b>	IDI live interview
<b>Atmosphere</b>	Relaxed working environment
<b>Raw notes</b>	<p>1) Yes.</p> <p>2) Referring to the first parallelogram shape of Aventra's procurement action which specifies on stock level sufficiency, the respondent pondered whether the public key has to be exactly customer-specific and suggests whether certain delivery-batch specific key would cut down the production time. The level of security would still be very high, because in any case the customers cannot download their own applets. The method suggested would cut down the needs to double check on the production workload, and therefore Aventra's process step of providing OC right after the said parallelogram.</p> <p>The longer process steps after inventory checking if the level of supply is deemed low and could be more expanded to provide clarity. The partial delivery undergoes a long process which can be simplified.</p> <p>It is worth investing time in developing the procurement process map. The respondent has an idea on developing production time slot feature within the ERP system, which informs production on the critical PO can be developed upon reaching the right side of the flow chart, on the process of providing a reasonable ETD to the customer. The time slot is based chronological PO inflow, first come first served. Time slot feature's objective is to optimize resources, as the ideal case scenario is if the production line is always working more than 90% of its capacity.</p> <p>The 2 months average consumption level has been based on experience; the average is calculated from <b>annual</b> sales log.</p> <p>NXP informs their customers 1 year before they stop manufacturing a certain module, this is also the reason why the current protocol for contact chip card stock replenishment is based on one year demand. The prospect for JCOP3 looks good and it seems that they will still be supplied for a long time. PVC discoloration in cards will not happen quickly because oxygen particles are at static due to airtight sealings in packages.</p> <p>The procurement model could also be based on forecast which products would turn into an actual PO.</p> <p>3) Referring to subcontractors' printing quality described in quality handbook Section 5.4., the criteria why long-term offset-printed cards chosen is due to the price and printing quality. Flexible schedule has been noted in Far Eastern or Southern European subcontractors.</p>

On the other hand, some key long-term chip card suppliers have been selected due to the following factors:

- Prime quality of the finished products. The countries where the products have been originated have centuries of craftsmanship tradition, with masters and apprentices.
- Strong moral and ethical concept. Some years ago, there was a case of ordered cards not meeting Aventura's thickness standard due to multiple coating of transparent film, thus they did not fit in one customer's card reader. The issue was brought directly to the supplier and new replacement products came promptly, free of charge and most importantly the procedure was hassle-free.
- Reliability and cooperative capability
- Availability of modules
- Close relationship with the OEM or a part of their inner circle.
- Technical support from an expert with whom you may have a direct communication with is widely available in Europe. According to the client company's experience, the communication with Far Eastern subcontractors is normally through their sales representatives, who tends to give the impression that they are manufacturers, but the operation turns out to be sales unit or an agency.
- Pre-set parameters and skills on pre-personalization

Aventura tends to gravitate towards a particular small-sized supplier because they seem to have similar wavelength. Another company offering similar range of products to the smaller competitor is a global giant, with extensive organizational structure, which makes it a bit challenging to receive support in some issues and tends to offer long delivery times.

4) Java Card works like a computer, it contains a programmable CPU instead of a hard-wired integrated circuit with no crypto operations, hence the device is able to protect data. The Java Card also has built-in hardware and software security features, unlike simpler memory modules.

While working as a CTO in a previous company before Aventura Oy, the respondent had a history with ATMEL who had the first EEPROM based CPU card, eliminating the economic risks of mask programmable technologies. However, instead of a full OS, it only contained a hardware layer library.

NXP was in the end selected when their Java card became available. It contains a full operating system, on top of which you create an application, called applet. The functionality can now be developed using a higher-level language, and many critical tasks are implemented in the OS. These days banking cards such as Mastercard and Visa are usually Java Card.

Aventura has always been devoted to NXP from the very beginning. They are among the first ones to utilize the technology. There is a significant privilege when the practice has been well rooted for decades.

	<p>5) A polished calculation model would work if future sales or consumption can be predicted. Forecast model based on quarterly calculation could be created for each highly demanded product. The respondent pointed out that enough information can be obtained from the market.</p> <p>6) Strong points suggested by the respondents are:          (+) It enables direct delivery from stock as often as possible due to close cooperation with reliable partners.          (+) Rather than required, the statement has been replaced with “manageable with a smaller storage space”.          (+) Correction to the statement that “all inventory products are still on-demand” have been replaced with the optimized model, not all have to still be on demand, but as many products as possible.</p> <p>Weak points suggested are as follows:          (-) It is highly demanding as it requires a lot of work effort, expertise, knowledge, and ability to analyse supply chain data.</p>
<p><b>Analytical observations</b></p>	<p>The interview was initially booked for 15-30 minutes, but the respondent has provided a lot of insights that the meeting was unintentionally stretched to 2 hours.</p> <p>1) The author gives full rights to retain consent to publish respondent’s name and work title at Aventura Oy. The consent can be retracted at any point before the final version of the thesis is submitted on 03.05.2023.</p> <p>2) The process workflow has been updated according to the suggested right-side expansion to be more observer friendly.</p> <p>PVC, a commodity plastic which is used in standard CR80 plastic cards turn yellow due to oxidation caused by oxygen, UV light exposure or heat.</p> <p>Quoting the author’s technical sales lecture notes, forecasting success rate on sales can be done by utilizing CRM tools which visualizes timeline and prospect rate of 0-5 in each phase. As one goes along the process further, the deal has a higher chance to be realized.</p> <p>Suitable sales process model for this case if for example the funnel path employed by Toyota, which features:          Awareness → Discovery → Evaluation → Intent → Purchase → Loyalty          The funnel path eases forecasting to see how many negotiations should be held.</p> <p>5) The level of demand rather fluctuates which is a hindrance to forecasting. The author disregarded to specify in the interview that the calculation model proposed would be based on published <u>academic</u> literature analysis.</p> <p>6) (-) The time pressure can be elaborated as fear of delays due to semiconductor OEM’s MTO (made to order) production strategy, where the products are tailored to the customer specifications. The products are not</p>

necessarily available directly on demand as they are not MTS (made to stock), which matches inventory levels with anticipated demand.

The respondent's anecdotes have been translated into English and tailored to serve the purpose of academic literature reporting. A copy of this field note has been sent to the respondent 27.01.2023 to ensure the document's credibility. The anecdotes have gone through another revision in 20.01.2023.

## **Data 1 Collection: Structured IDI Interview Questions to Management Role 1**

Would you give consent that your title at Aventura Oy would be displayed on the thesis work along with name, or should the quotes gathered be documented anonymously as Manager N? The answers gathered would greatly benefit the author's Master thesis current state analysis and could further be implemented in her professional work.

On a scale from 1 – 5, where 1 means strongly disagree, 2 means disagree, 3 means neutral, 4 means agree and 5 means strongly agree; what is your professional take on the following clauses (if you disagree, feel free to express the following clauses differently using your own words):

- 1) The global chip shortage affects the client company's procurement process, and the ripple effect is also felt by production.
- 2) The global chip shortage affects the delivery lead time and poses higher risk of delays.
- 3) Prolonged chip shortage imposes tighter deadlines on production, which forces simultaneous operation on multiple machines with different task configurations.
- 4) Repeated spontaneous agile manufacturing improvisation methods such as backwards product replacement has been conducted to respond quickly to customer needs and market changes while still controlling the costs and quality. (Martin & Towill, 2001, pp. 236-237)
- 5) High customer satisfaction level is harder to maintain due to chip shortage issues.
- 6) The client company would benefit from a procurement model based on best practices found on existing literature analysis.

- 7) The client company would benefit from a delivery agreement model with chip suppliers with specifications corresponding to our quality handbook and standardized lead time, depending on the type of products supplied.
- 8) Production would benefit from procurement status update in the beginning of each business week to co-design a production time slot.

Thank you for your time and patience.

### **Suomenkielinen käännös: Data 1 keräily: Strukturoidut IDI-haastattelukysymykset Päälikön rooli 1:lle**

Antaisitteko suostumuksen siihen, että työnimikkeenne Aventra Oy:ssä näytettäisiin opinnäytetyössä nimenne kanssa, tai dokumentoidaanko lainauksia anonyymisti Päälikön rooli N:nä? Kerätyt vastaukset hyödyttäisivät suuresti kirjoittajan pro gradu -työn nykytilan analyysiin ja niitä voitaisiin soveltaa jatkossakin hänen ammatillisessa työssään.

Asteikolla 1–5, jossa 1 tarkoittaa täysin eri mieltä, 2 tarkoittaa eri mieltä, 3 tarkoittaa neutraalia, 4 tarkoittaa samaa mieltä ja 5 tarkoittaa täysin samaa mieltä; mikä on ammatillisenne näkemyksenne seuraavista lauseista (jos olette erimieltä, voitte vaihtoehtoisesti ilmaista seuraavia lauseita eri tavalla omin sanoin):

- 1) Maailmanlaajuinen sirupula vaikuttaa asiakasyrityksen hankintaprosessiin ja sen seuraukset on havaittu myös tuotannossa.
- 2) Maailmanlaajuinen sirupula vaikuttaa toimitusaikaan ja lisää viivästymisriskiä.
- 3) Pitkittynyt sirupula asettaa tiukemmat määräajat tuotannolle, mikä pakottaa samanaikaisen käytön useille koneille, joilla on erilaisia työkonfiguraatioita.
- 4) Toistuvia spontaaneja ketteriä (ENG: agile) valmistusimprovisaatiomenetelmiä, kuten taaksepäin vaihdettavia sirukorttiaihiota, on tehty vastaamaan nopeasti asiakkaiden tarpeisiin ja markkinoiden muutoksiin samalla kun kustannukset ja laatu ovat hallinnassa. (Martin & Towill, 2001, pp. 236-237)
- 5) Korkeaa asiakastyytyväisyyttä on vaikeampi ylläpitää sirupulaongelmien takia.



- 6) Asiakasyritys hyötyisi olemassa olevasta kirjallisuusanalyysistä löydettyihin parhaisiin käytäntöihin perustuvasta hankintamallista.
- 7) Asiakasyritys hyötyisi toimitussopimusmallista sirutuotteiden toimittajien kanssa laatukäsikirjaamme vastaavien eritelmien ja standardoidun toimitusajan mukaan toimitettujen tuotteiden tyypistä riippuen.
- 8) Tuotanto hyötyisi hankintatilanteen päivityksestä jokaisen työviikon alussa tuotannon aikavälin suunnittelua varten.

Kiitos ajastanne ja harkinnastanne.

### Field Notes: Current State Analysis Interview with Management Role 1

<b>Interview participant</b>	Management Role 1
<b>Place</b>	Production area
<b>Time</b>	24.01.2023, 14:40 – 14:50
<b>Duration</b>	10 minutes
<b>Language</b>	Finnish (clarifications in English)
<b>Setting</b>	IDI live interview
<b>Atmosphere</b>	Semi-formal, under high work capacity
<b>Raw notes</b>	<p>1) 4 / agree.</p> <p>2) 5 / strongly agree. There have been cases where the global chip shortage has affected the production line as well as business.</p> <p>3) 3 / neutral.</p> <p>4) 4 / agree.</p> <p>5) 3 / neutral. In general, customers tend to be understanding that the ideal lead time (hence high customer satisfaction level) is harder to maintain due to chip shortage issues. Especially because this worldwide phenomenon affects every supplier. Even when the challenges have been described and the phenomenon is known to general public, some customers disregard the situation and press on deadlines that are challenging to achieve.</p> <p>6) 5 / strongly agree.</p> <p>7) 4 / agree.</p> <p>8) No mark was given from the last statement, but from the tone of the feedback, it sounds like a 3. Management Role 1 comments that the weekly procurement status update for co-designing production time slot seems like a good idea but would not work due to limited time imposed.</p>
<b>Analytical observations</b>	<p>The author was in the end grateful that the correspondent agreed to participate in the quick interview until the very end. Despite a certain degree of reluctance on the scheduled time slots, the author tried to persuade and highlighted the importance of the interview process of production as a major part of the supply chain, which is naturally impacted by the chip supply shortage.</p> <p>The interview questions were requested to be revealed in advance in two separate occasions, but the author decided to object because it risks obstructing the linear flow (overly brief anecdotes might be given to serve several statements at once instead of one at a time), which could result in confirmation bias. The focus might be shifted to textual rather than contextual on the phenomenon at hand.</p>

8) Although the weekly production scrum idea was dismissed, the author continues to list order ETDs on the production whiteboard while tracking, notifying if a deadline is closely approaching, and offer assistance if needed.

All the in-house tools and machinery require regular servicing and maintenance in order to prolong their lifespan and to ensure the best quality in the end-product. Employees are responsible to monitor the condition of their workstations and inform the support team if the issue cannot be fixed in a reasonable time. Aside of maintaining the machinery throughout their entire lifespan, Aventura strives to acquire equipment with extended warranty in order to receive on-time service help in case of defects or malfunctions. (Aventura Oy, 2022, p. 25)

The correspondent's testimonies have been translated into English and the brief ones were expanded to illustrate the complete meaning of the anecdotes, hence serves the purpose of academic literature reporting.

## Questionnaires to Key RFID and Contact Chip Suppliers

The following questionnaire was made online through Microsoft Forms between 24.01.2023 - 03.02.2023.

Dear Aventra Oy's supplier,

Thank you in advance for your participation in this supplier questionnaire.

All responses are highly confidential and shared only internally. The results gathered will significantly benefit the author's Master thesis study and could further be implemented in Aventra Oy's procurement process analysis.

The questionnaire would take approximately 2 - 10 minutes to complete.

For further inquiries regarding this questionnaire, please contact [kanya.auvinen@aventra.fi](mailto:kanya.auvinen@aventra.fi)

### 1) Company name \*

The company name will not be published and will be mentioned as Supplier 1, 2, 3, n... within the study.

### 2) Which process best illustrates your manufacturing workflows? \*

- MTO: Make-to-order
- ATO: Assemble-to-order
- MTS: Make-to-stock
- ETO: Engineer-to-Order

### 3) How has your company handled its finances during post-Covid-19 era? \*

Result from the last financial statement.

- Extremely well. Revenue growth ratio of over 25%
- Very well. Revenue growth ratio of 10 % - 24%
- Fairly well. Revenue growth ratio of 1 % - 9 %
- Declining trend, negative growth

4) Which NXP® Semiconductors smart cards do you supply? \*

The products listed belong to Aventra Oy's range of products.

- JCOP3 contact Java Card
- JCOP3 dual interface Java Card
- JCOP3 Java Card hybrid with Mifare DESFire
- Mifare DESFire EV
- Mifare Classic 1K S50
- Mifare ICODE SLI X / X2
- Mifare Ultralight

5) Post-pandemic worldwide chip shortage affects delivery lead-time for these chip products? \*









8) In your professional opinion, how long would it likely take for supply chain disruption to subdue for each of the following chip products? \*

	This year	1 - 2 years	3 - 5 years	Hard to predict	We do not provide this chip product / Hard to know
JCOP3 contact Java Card	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
JCOP3 dual interface Java Card	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
JCOP3 Java Card hybrid with Mifare DESFire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mifare DESFire	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mifare Classic 1K S50	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mifare ICODE SLI X / X2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Mifare Ultralight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other chip products mentioned in Question 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9) How does your company mitigate chip shortage issues? \*

10) Feel free to write any notes, comments, or feedback to this questionnaire.

(\*) = Required field

## RFID and Contact Chip Suppliers' Questionnaire Results and Interpretations

Microsoft forms online questionnaire was sent to 58 sales representatives from 46 companies, supplying the most critically scarce chip modules. Their locations can be observed in Figure 26.



Figure 26 – Locations of chip supplier questionnaire respondents

The questionnaire was released during the busiest week of the year between 20.01.2023 – 03.02.2023. Even though the questionnaire yielded 41 % response rate, the author was very satisfied with the result because all of Aventura's key suppliers managed to participate.

From the manufacturing workflows question, the following result can be observed in Figure 27.

● MTO: Make-to-order	17
● ATO: Assemble-to-order	7
● MTS: Make-to-stock	5
● ETO: Engineer-to-Order	4
● Other	2



Figure 27 – Manufacturing workflow of suppliers

Almost all participants answered MTO as manufacturing method. With the nearest chip supplier answering only MTO, which could explain the longer lead time in comparison to other suppliers. Aventura’s key supplier answered MTO, ATO and MTS and their supply chain agility during shortage has been highly appreciated. From the ones answering other methods, one mentioned offset-printing according to design specifications, which should be categorized under MTO; and another mentioned that they have blank cards on stock, which should be categorized under MTS.

As observed in Figure 28, most suppliers handled their finances very well and their revenue growth ratio is at 10 % - 24%.

How has your company handled its finances during post-Covid-19 era?

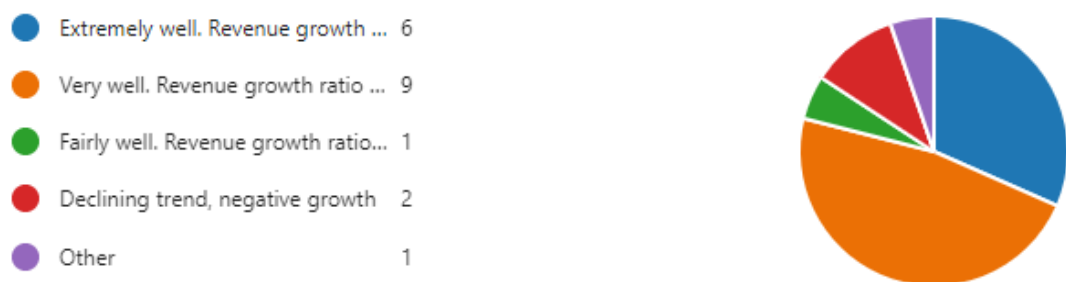


Figure 28 – Revenue growth ratio of suppliers during post-Covid-19 era

Two companies located in the Far East reported that the company is undergoing a declining trend, which translates to negative growth. One company reporting other reported 49 % revenue growth in their last financial statement, which falls to extremely well category.

Figure 29 represents the type of NXP® Semiconductors smart cards supplied.

4. Which NXP® Semiconductors smart cards do you supply?

[More Details](#)

<span style="color: blue;">●</span> JCOP3 contact Java Card	7
<span style="color: orange;">●</span> JCOP3 dual interface Java Card	8
<span style="color: green;">●</span> JCOP3 Java Card hybrid with Mif...	7
<span style="color: red;">●</span> Mifare DESFire EV	19
<span style="color: purple;">●</span> Mifare Classic 1K S50	19
<span style="color: brown;">●</span> Mifare ICODE SLI X / X2	18
<span style="color: pink;">●</span> Mifare Ultralight	19
<span style="color: grey;">●</span> Other	24

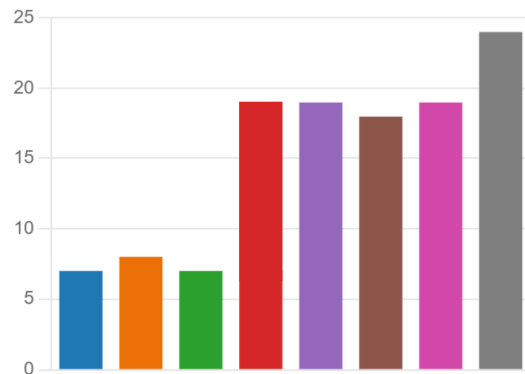


Figure 29 – NXP® Semiconductors smart cards supplied.

As observed in Figure 29, around half of the respondents provide JCOP3 contact or dual interface Java Cards. Aventra has purchased JCOP3 Java Cards previously from two of the respondents. Java Card is the preform used for embedding Aventra’s MyEID applet. In case of supplier diversification, this questionnaire has provided knowledge that another European supplier also provides contact and hybrid cards, as well as one Far Eastern supplier which answered that their revenue is currently at a declining trend. The next step would be to request test cards and see if they meet Aventra’s standards and compatibility.

Mifare DESFire chips which contain full microprocessor and is equipped with the most secure 128-bit encryptions. Even if the chip is generally supplied by many as observed in Figure 29, but the availability is subjected upon request and the cost heavily fluctuates.

Change in lead time for each NXP® chips post-pandemic can be observed in Figure 30.

5. Post-pandemic worldwide chip shortage affects delivery lead-time for these chip products?

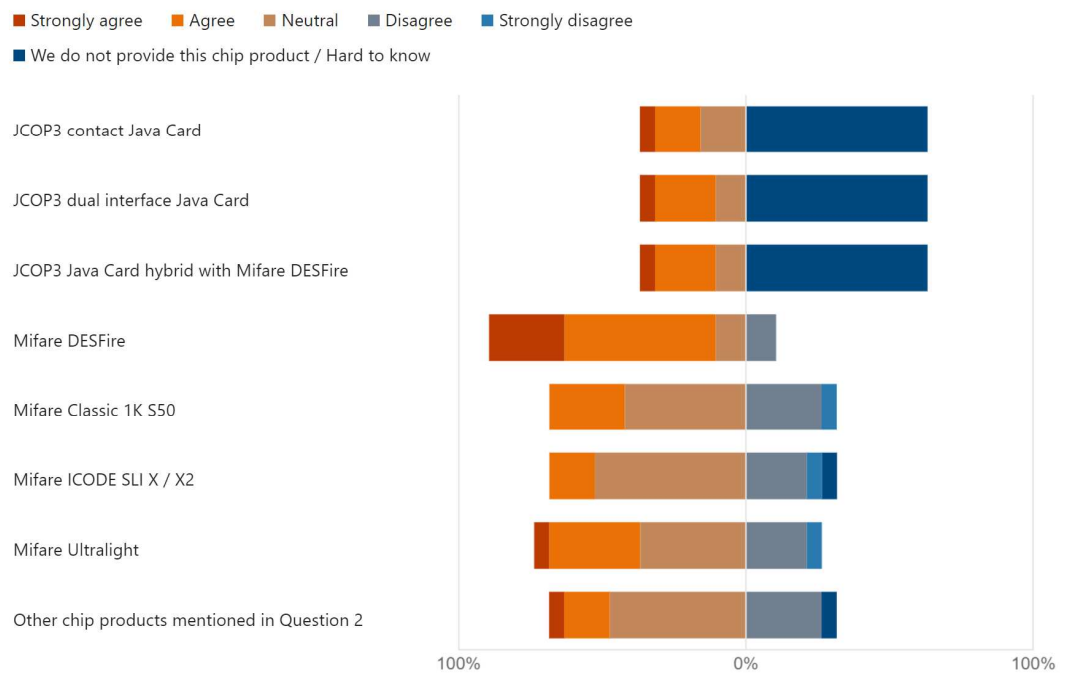


Figure 30 – Global chip shortage impact to the lead-time

As illustrated in Figure 30, most suppliers either strongly agree or agree that Mifare DESFire’s lead-time is heavily affected by global chip shortage. Most suppliers either do not provide JCOP3 Java Cards, or those who do agree that the lead-time has been affected by worldwide chip shortage.

Questionnaire results show the average delivery time for chip products before 2020 and in spring 2023 separately. To ease assessment, the charts have been separated into contact and RFID chip cards, with timeline on top of one another. The result for contact chip and hybrid cards can be viewed in Figure 31.

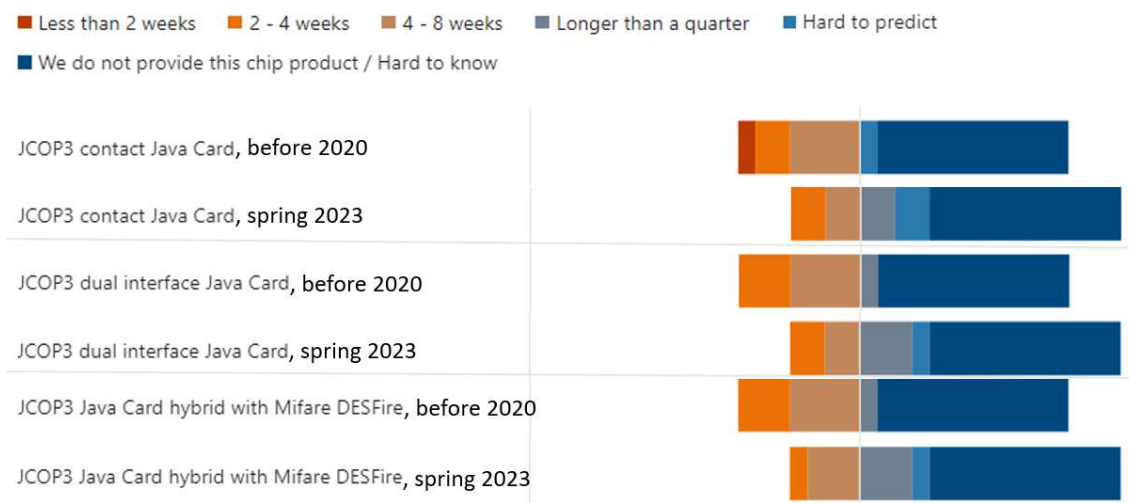


Figure 31 – JCOP3 contact and hybrid cards’ average delivery time before 2020 and in spring 2023.

As one can observe in Figure 31, there is a significantly larger number of suppliers who either does not produce the contact chip product or the delivery time is rather unknown. One supplier was previously able to dispatch Java Card JCOP3 in less than two weeks, but by spring 2023, the shortest delivery time reported is at 2 – 4 weeks. The average lead time for many contact chip cards before 2020 is 2- 4 weeks, and by spring 2023 the reported average is longer than a quarter. More have reported by spring 2023 that the lead time is hard to predict, which might mean that the chip shortage issue is not going to ease any time soon.

NXP’s RFID chip card average delivery time difference before 2020 and in spring 2023 can be seen in Figure 32. The DESFire has been observed to be the RFID chip suffering the worst impact of global chip shortage, even at times at a similar level compared to the contact chip cards.

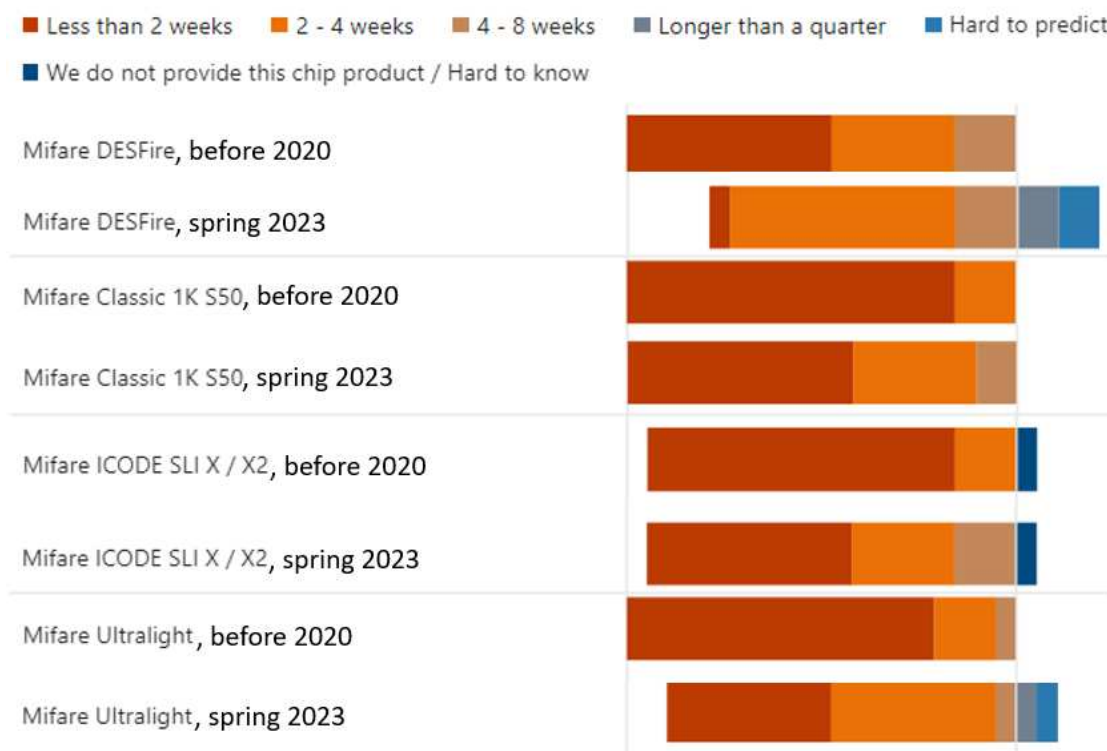


Figure 32 – NXP's RFID chip card average delivery time before 2020 and in spring 2023

As observed in Figure 32, the average lead time for Mifare DESFire and Ultralight is under 2 weeks before 2020. By spring 2023, the lead time is predicted to be 2 – 4 weeks average and the number of suppliers reporting that the lead time could be longer than a quarter or it is hard to predict have increased.

The suppliers were asked according to their professional opinion when the supply chain disruption is predicted to subdue for each of the NXP chip products. The result can be observed in Figure 33.

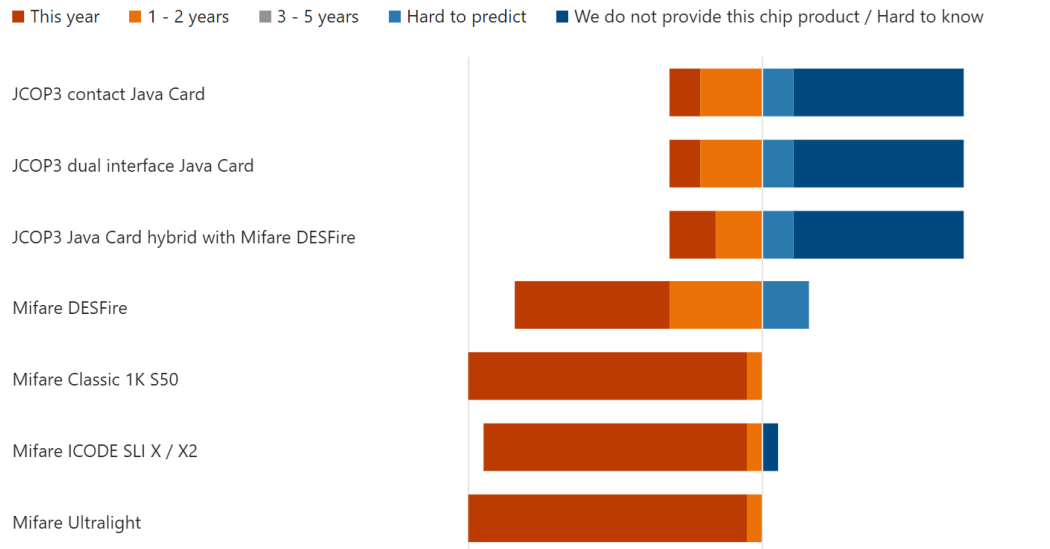


Figure 33 – Predicted moment when the supply chain disruption going to subdue for each chip products.

As observed from the answers provided in Figure 33, either suppliers do not provide the contact or hybrid chip cards or it might take 1 – 2 years for the shortage to subdue, quite a big portion answered that it is hard to predict when the situation going to subdue. RFID chips’ shortage is expected to ease this year by most suppliers, with some frankly responding that the shortage for DESFire chips would subdue in 1 – 2 years or that it is the hardest chip supply fluctuation to predict, which is more realistic.

Reading onto the required response on how each supplier mitigate the chip shortage issues, the responses can be summarized as follows:

- Key Supplier 1 checks the customer demand and order the chips in advance. They try to build up a stock.
- Key Supplier 2 utilizes stock management and source alternative (functionally equivalent) products from other semiconductor manufacturers. They added that due to JCOP3’s partial EOL status, the anecdotes have been written partly for JCOP4 products.



- Aventura has never previously purchased JCOP3 Java cards from 5 other suppliers who informed to sell them. Their anecdotes are as follows:
  - One potential JCOP3 Java card supplier located in Europe informed that the chip shortage issue has been mitigated by forward buying stocks with key NXP distributors and other chip manufacturers and having regular meetings with them to forecast (at least quarterly) to forecast requirements. The supplier then has a large capacity to make wafers into inlays / prelams / finished cards. Through communication with customers, they stock wafers for most chip types, which enables them to respond quickly to partner requirements. One of their correspondents answered similar lead time for contact chip card such as Key Supplier 1 and 2, and another representative gave half shorter lead time.
  - One Far Eastern Supplier A who informed revenue growth rate of 10 – 24% stated that they have long-term and stable supply channels. Some large projects are registered with NXP, hence direct regular supply of their chips. 4 - 8 weeks of lead time was informed, and the chip shortage subdue is hard to predict according to them.
  - Another Far Eastern Supplier B who also informed revenue growth rate of 10 – 24% informed that they have a stable stock from the chip suppliers. 2 – 4 weeks of lead time was informed, and they are certain that chip shortage issue will subdue in 2023.
  - Far Eastern Supplier C who informed that the lead time for JCOP3 is hard to predict stated that their action to mitigate NXP chip supply shortage is by finding compatible chips from other suppliers, which is not feasible to Aventura's solution.
  - The last Far Eastern Supplier D who informed declining trend of revenue growth informed lead time of contact chip products to be longer than a quarter, although surprisingly their DESFire lead time is less than 2 weeks. They informed that no good solutions are to be found to mitigate

NXP chips shortage due to 30 % - 200 % increased procurement costs. They also informed that the biggest agents seem to have no stock, and although some trading companies have stock, but the price is extremely inflated. Like Far Eastern Supplier C mentioned, many of their customers also turn to other contact chip brands, which is not feasible for Aventura's solution. As many suppliers have informed before while unable to supply DESFire chips, Far Eastern Supplier D believes that NXP did poorly on chip supply management as chip price was seen to inflate every day. Some suppliers therefore see the chip purchase as a risk which generates lower profit than in the past.

- As Aventura's main product, MyEID applet is embedded on Java Card JCOP3, the following risk mitigation strategies should be used as risk mitigation strategies for RFID modules including DESFire , whose lead time has been increasingly uncertain as observed in Figure 32.
  - European RFID Supplier A has alleviated their clients' chip shortage issue by offering printed card recycling service for chip cards that have not been encoded or those that can be flashed back to unencoded state. The cards are then recycled and turned into new ones. They stock DESFire EV2, EV3 as the pandemic started and EV1 stock has been replenished again. In some cases, they are able to emulate the output of one chip with another depending on the functionality.
  - European RFID Supplier B operates on MTO model. They mass purchase popular chips to stock, and work on smaller storage upon request for less popular chip products.
  - Aventura has previously purchased chip products from 3 of the following Far Eastern chip suppliers. Their anecdotes have been compiled into one paragraph. One of them stated that they reserve chip products in advance from NXP with whom they argue to have stronger relationship with compared to the other suppliers, hence they have more in stock. Another

conducts chips allocation on a quarterly basis and optimize their supply chain. The third one increases their supply channels to mitigate the risk.

- Aventura has previously never purchased chip products from 6 of the following Far Eastern chip suppliers, but their anecdotes have compiled regardless because they might potentially offer an insight or a solution to this thesis study. The first correspondent states that they source chips from multiple channels, order regular chips based on production data even when there were no confirmed orders, recommend clients to use substitute chips for some projects and they register and demand chips directly from NXP in some bigger scale projects to ensure sufficient supply. Another supplier tries to forecast demand in advance and replenish stock depending on OEM's inventory level. The third correspondent from this subgroup ensures a stable supply with an NXP agent due to an existing contract, although the price might be adjusted upon request. Three of the last correspondents offer compatible chips which is not a feasible solution for Aventura.

## Business Data Analysis and Visualization: Written Exercise and Laboratory 4

Figure 34 has been chosen to represent CSA (current state analysis) on the author's thesis topic surrounding worldwide chip shortage and its impact on PKI card manufacturers. Even though one tree map figure depicting the number of individuals employed in each department or the roles they undertake within the organization, has been included in Section 1.1.

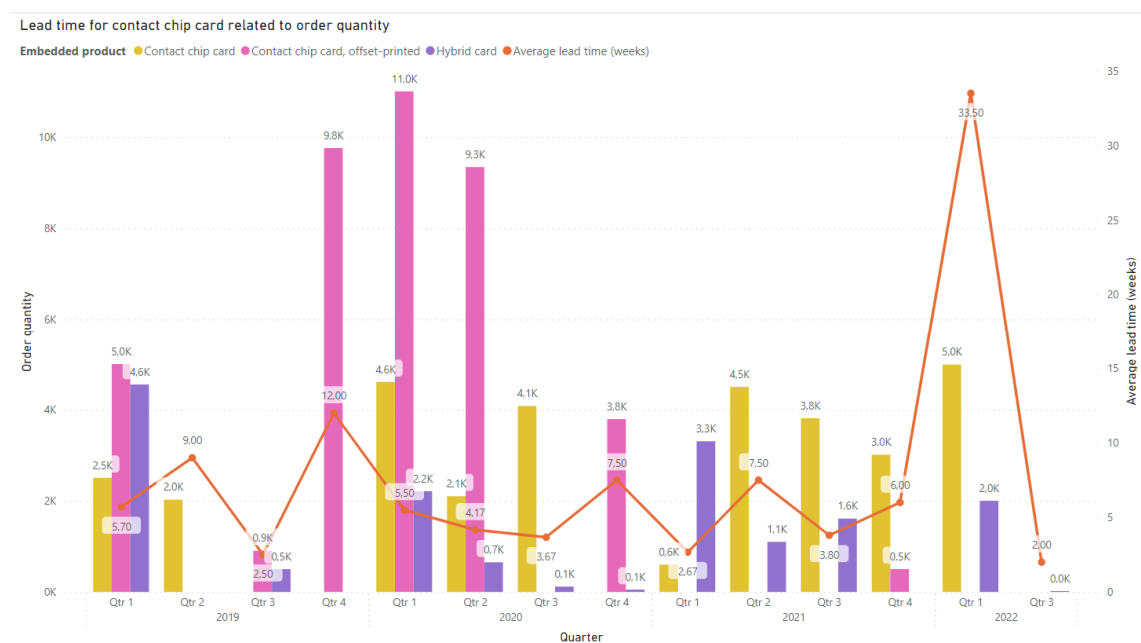


Figure 34 – Lead time for contact chip cards related to order quantity.

Procurement data from Aventura Oy's ERP system has been employed to generate Figure 34. Generated spreadsheet consists of the following information:

- Order and delivery dates, earliest retrieved from 2019 to illustrate the lead time situation prior to the pandemic.
- Embedded products that have suffered the biggest impact from global chip shortage:

- Contact chip card (both based on the newer JCOP3 J2H145 and the EOL JCOP2 J2A081).
- Contact chip card with offset-printing.
- Hybrid card (dual interface card utilizing both the contact chip and Mifare DESFire or Mifare Classic RFID chips).
- Mifare DESFire card.
- Mifare DESFire keyfobs.
- Quantity received.
- Lead time in weeks (the average has been utilized in Figure 34).

The following parameters have been disregarded from the data collection:

- Suppliers, because the best offer has always been prioritized.
- Inflation rate and its effect on price.
- Chips with basic protection security level such as Mifare Classic, Ultralight or ICODE SLI X.

The spreadsheet has been sorted by order date (oldest to newest), and the second hierarchy represents order quantity. Highlight cell rule has been employed on the order date in order to pay a closer attention and eliminate duplicates, because the author did not intend to list every one of the chip types provided by Aventura's ERP, but rather highlighting the common chip type that could benefit from the adaptation plans as the core objective of the thesis study.

Power BI's line and clustered column chart have been chosen to represent the data. Readability has been improved by enabling data labels. The x-axis

timeline is represented quarterly. Orange and chip yellow were chosen as the most important highlights to represent Metropolia and Aventura Oy as clients on this thesis study.

## Raw Field Notes: Solution Building Workshop for Initial Proposal

<b>Workshop participant</b>	Timo Markkula, MSc., Senior partner (Aventra Oy's CEO 2004 – 2021)
<b>Place</b>	Aventra's meeting room
<b>Time</b>	14.03.2023 15:30 – 18:00
<b>Duration</b>	2,5 hours
<b>Language</b>	Finnish and English terms provided by literature
<b>Setting</b>	IDI live interview
<b>Atmosphere</b>	Ambient, supportive, and quite relaxed
<b>Raw notes</b>	<p>Some of the following raw note anecdotes might include the author's views and findings in order to assist the reporting flow.</p> <p><b>Section 4.1 Review – Enhancing KSRM</b></p> <p>The respondent agrees on maintaining a good relationship with suppliers to a certain extent and through supplier risk analysis.</p> <p>One card reader OEM is known to boosts sales by spinning a severe shortage scenario in order to push the whole batch, even if there is a known risk that the product will turn EOL in the foreseeable future. Aventra still took the deal regardless the high depreciation risk because the products would still bring more coverage to the webshop.</p> <p>Regarding Toivanen's (2017) supply chain strategy to adapt to volatility, the respondent stated the following:</p> <ul style="list-style-type: none"> <li>• Increasing supply chain flexibility or resilience: There might be only one supplier with the ability to comply.</li> <li>• High faith has been placed on suppliers as there is no QC inspection procedure in place yet for incoming items. Some suppliers with lower inclination towards CRM might neglect quality.</li> <li>• Some TQM practices are already in effect, such as detecting and eliminating manufacturing errors. Other aspects such as streamlining supply chain, improving customer experience, and making sure personnels are fully trained would also be beneficial.</li> <li>• CE approach would be more applicable to Aventra's software development but not supply chain process. Waterfall in a certain order is currently employed.</li> </ul> <p>Concerning Miocevic &amp; Crnjak-Karanovic's (2012) KSRM dimensions, the respondent stated that managerial framework implementation is done through market monitoring and conversation with suppliers every few weeks.</p> <p>Considering SRM phase model by Moeller, et al. (2006), the respondent summarized the following:</p> <ul style="list-style-type: none"> <li>• Out-supplier management model was agreed upon for future prospect if other suppliers disappear or dissolve due to natural cause, even if resource-draining, poses a higher risk and requires compatibility testing.</li> <li>• Maintaining in-suppliers through alternation is deemed important.</li> </ul>

- Set-up management to build partnership has been done with Key Supplier 2.
- Development management with “real value enhancers” to retain suppliers and ensure that they neither switch to competitors nor terminate partnership is already in practice.
- Contract management: Very few contracts are in place with the suppliers, most of them concerns larger customer projects. The respondent ponders on the cost and if it could positively impact the ETD, also whether it should be done by case.
- Disturbance management: Force majeure (legal contracts provision that shields parties from liability in the case of a significant unanticipated occurrence). In the event of a termination due to natural ending, it might be costly to then start seeking an alternative supplier when KSRM has already been established.
- In-supplier dissolution management through supply base reduction:
  - Quality and service enhancement: Supplier-based contract could be in line with specified standards found in Aventura Oy’s (2022) quality handbook in order to produce a high yield. For a high brand reputation, dual interface cards have been deployed by some customers even if they mainly use the RFID interface for access permit without needing the contact chip for signing into personal devices. In dual-interface card manufacturing process, RFID chip is integrated within the card before the contact chip in dual-interface card. Suppliers promise an annual maximum defect rate of 1%.
  - Entering a long-term agreement with key suppliers is not feasible, unless they can always agree to supply.
  - Devoting efforts to top suppliers have already been in practice.
  - Establishing partnership with strategic supplier is not feasible in times of scarcity.

On the subject of theoretical frameworks featured in (Mantere, 2015), the respondent commented the following:

- Hybrid exploratory control archetype with low programmability:
  - Typical supplier ranking could be beneficial.
  - Strong cooperation is key but not shared responsibility. Order still flows constantly to the suppliers even though increased wafer price has been observed. In case of customer’s order confirmation delay after initial offer, the suppliers might be the ones bearing possibly increased wafer cost or the cost might be split in half. As reported in 3.5.3, Aventura bears the cost of defective amount which passed supplier’s QC and there is need for recording the amount for accounting purposes. From each batch, the reported amount of defects may be processed as a store credit which could be utilized in the next order.

Considering management control systems by Malmi & Brown (2008), the respondent stated the following:

- In cultural controls, cooperative conflict resolution is hard to implement. Through a case example of one open market purchase originating from the far east, the supplier offered a refund, but Aventura had to bear the



high shipping cost. When that was rejected, they offered redundant items as a stock clearance method.

- Planning within an inter-organizational context:
  - Long-term planning and structure can be incorporated to a customer's contract, but not suppliers. With suppliers, agreement can be achieved through negotiations when there is a solid chemistry. Trust has a higher value than contract, which suggests a lower trust level.
  - Action planning suggestion was accepted through short-term collaboration.
- Cybernetic controls, especially in budgeting is normally applied to us by customers.

#### **Section 4.2 Review – Supplier Diversification Practices**

Pertaining to Do's (2022) guidelines to alleviate each shortage phase, the respondent stated the following:

- In pre-disruption phase, risk management practices such as:
  - Employing up to four alternative suppliers for the same component is deemed a good practice. When it comes to suppliers' contact chip procurement, it all boils down to whose turn it is to receive the reel of unfused contact chips (containing 10 000 pcs) from the OEM. Even when the reservation fee is paid in advance, in general suppliers are against reserving impacted chips because there is a risk of lost currently prospective sales when other customers also demand the same chips, and the items have continuous flow of purchase. Unlike machineries, contact chip cards do not usually have a risk of depreciation and amortization. Customer loyalty is still gained even if longer lead time is imposed as the products are already part of the customer's fundamental offering.
  - Utilizing alternative components which requires R&D agility to test on alternative materials have been approved.
  - Supply chain alignment practice in which ERP systems handle end-to-end information flows and monitor the most recent state of various supply chain operations is already in place.
- During and post-disruption phase, the following responses implemented by other companies such as:
  - Escalation is nice to have but not compulsory. Whereas negotiations to deny any postponement or request for improvement will not help in waver procurement.
  - Frequent follow-ups via active discussions with clients, regular meetings and (daily) conversations with suppliers is a must-have.
  - Definite must-have is observed from increasing buffer stock by alternating system parameters, boosting safety stock levels, expanding purchase sizes, and compromising purchase inventory rotation. Customers must also be advised to use a similar strategy to assure delivery accuracy during the shortage.
  - The respondent stresses on the importance of stock value optimization, otherwise the capital would be tied up in the inventory which poses a high risk.

- While proactively alternating suppliers is accepted (through testing), but additional purchases from local markets is not a good practice because they tend to be Aventura's competitor.
- One has to consider the freight cost in comparison to the fluctuating exchange rate prior to purchasing from Far East.
- Demand management which identifies which customers require the items first have been accepted, although a contract is always enough as a prioritization factor than a contract penalty. Customers are aware of Aventura always doing their best to meet demands.
- Throughout the whole crisis, retaining agility in the timespan of crises through a culture of change, supportive top management and strategic cooperation with supply chain partners are already in place. Especially IT capabilities through an ERP system which can track total lead time.

Relating to Mahsa, et al.'s (2019) multinational selection criteria in volatility era, the respondent stated the following:

- Selecting numerous suppliers with varying lead times to provide constant commodity supply: Purchasing a small batch of hundreds at a higher price seems to be a good practice, but not if MOQ is 1000 pcs. The determining annual purchase should still be made from the most strategical source.
- Low customer specific items, which require no assembly such as card accessories are easier to procure from multiple suppliers.
- Aventura has an actively implemented risk prevention measures which is not yet documented, but there is a tendency to choosing suppliers with shorter lead times and higher pricing.

Regarding Swaminathan & Shantikumar's (1999) method of employing the identical number of potential suppliers that Aventura should utilize to satisfy their demand request in a discreet demand environment, the respondent stated that currently the demand is not quite discreet, hence the price is quite stable for the impacted items. When the market sees supply and demand stability, then the products can be reserved without risking the supplier.

#### **Section 4.3 Review – Delivery Terms Agreement Model Creation Plan**

Concerning logistics service contracts overview by Forslund (2009), the respondent highlights the following:

- Current size of Aventura Oy elaborated in Section 1.1 upon the remarks which states that larger organizations are anticipated to have a higher degree of formalization. Otherwise, it would be sensible to employ.
- Material purchases are quite small for it to be made into a complete contract.
- Many customers manage performance with ISO standards, which is already implemented with Aventura's tangible and intangible products. As a low-level formalized scenario which enables improvement benefits achievement, the standards have been elaborated in Aventura Oy's (2022) quality handbook concerning standard thickness. Standard capacitance

	<p>and pantone colour profile resemblance have yet to be defined in more detail.</p> <ul style="list-style-type: none"> <li>• A degree of flexibility has been observed by KSRM, even without an implemented formal commercial contract.</li> <li>• In a mass purchase situation, on-time delivery and flexibility are essential performance metrics.</li> </ul> <p>Considering incentives and penalties model observed in Forslund (2009), the respondent stated that:</p> <ul style="list-style-type: none"> <li>• Contract which states supplier incentivization for on-time delivery is acceptable. The reasonable annual amount could be calculated percentagewise from each component, which rewards supplier on ASAP delivery and flexibility to top up if needed.</li> <li>• On the other hand, no supplier would agree to a late delivery penalty which includes predetermined sum that the supplier needs to pay with incurred loss estimation.</li> <li>• Performance reward for those performing above the agreed targets will receive a growing purchase confidence for future procurement. Monetary reward is not a good strategy due to the little profit left from implementing the model.</li> </ul> <p>While assessing Christopher &amp; Towill’s (2001) supply chain strategies and execution model, the respondent commented the following:</p> <ul style="list-style-type: none"> <li>• Assessing Figure 15 – Differences between lean and agile paradigm based on market qualifiers and winners , Aventura’s supply chain is based on lean paradigm but in periods of scarcity, the agile method has been more concentrated on.</li> <li>• While assessing Equation 1 - Supply chain total PDP (product delivery process) costs , which specifically summarized that excessive lead-time and cost are waste, the respondent commented that the delay might result in bad reputation and reputation is a valuable commodity. Down time caused by time slot interruption which was originally reserved for a specific task even with ABC in place cannot be invoiced to the customer. Deployment largely depends on the customer’s commitment towards the project. Customers make final decisions based on Aventura’s viewpoints and Aventura holds on before the installation decision is finalized by the customer’s authority figure.</li> </ul> <p>While combining lean agile paradigms according to Christopher &amp; Towill (2001), the respondent commented the following:</p> <ul style="list-style-type: none"> <li>• The de-coupling point is deemed a good practice. De-coupling enables lean up to final configuration, which is then proceeded with agile when the precise customer requirement is known. De-coupling point also enables tracking the total amount of defects from each batch instead of order. The suggested approach has been elaborated in Section 3.5.3.</li> </ul>
<p><b>Analytical observations</b></p>	<p>The interview was initially booked for 45 minutes, but the respondent has again provided a lot of precious insights that the meeting was unintentionally stretched to 2,5 hours.</p> <p><b>Section 4.1 Review – Enhancing KSRM</b></p>

Tangible items described under Section 4.1 review tend to be less liquid due to their nature of taking more time and resources to sell them.

Concerning Toivanen's (2017) supply chain strategy to adapt to volatility, the author added that S&OP, related to order quantity equals to production daily quantity is already implemented. Supply chains are built on lean, which makes it cost-effective and predictable. IMS parameter poses flexibility and is able to react quickly to market changes.

Regarding Miocevic & Crnjak-Karanovic's (2012) KSRM dimensions, the author added the following:

- Aventura seldom monitors the strategic supplier's value stream. It relies on suppliers update information. They are obliged to respond accordingly in case of mishap.
- Supply chain monitoring is enabled by the in-built function within the ERP systems (purchase order status turns red in case of delay).

Considering SRM phase model by Moeller, et al. (2006), the author has observed the following:

- In-supplier dissolution management through supply base reduction:
  - Becoming more customer-centric has been observed in one loyal customer where their preference towards a certain thickness of card body has evolved to the standard for that particular RFID card.

Semiconductor used for cards also compete with other markets such as cars, PCs, and gaming consoles. Supply chain priority for identification and security systems seems to be imbalanced compared to entertainment commodity.

Regarding management control systems by Malmi & Brown (2008), the author has observed the following:

- Cybernetic controls, especially in budgeting is already applied while the author compares offers received from the open market for RFID products.
- For reward and compensation in buyer-supplier interactions:
  - Basing the supplier rank according to their performance is not yet in place, although preference is already somewhat in effect.
  - Incentive-based learning within the alliance to enhance transparency and reciprocal behaviour has already been applied unconsciously through multiple suppliers.

#### **Section 4.2 Review – Supplier Diversification Practices**

Concerning Do's (2022) guidelines to alleviate each shortage phase, the author commented the following:

- During and post-disruption phase, the following responses implemented by other companies such as:
  - Purchases from open market in order to boost performance is nice to have, although the compatibility must be tested in advance.

- Some suppliers actively use third party communication platforms which lacks documentability even if it has been constantly advised against.
- Demand management which identifies which customers require the items first have been accepted. The author added that in undelivered orders, total purchase value is often prioritized.

In Cadot, et al.'s (2014) import diversification with quality search, Aventura is most likely to import items of higher quality as it is located in a country with higher income levels, than a country with more trade openness who imports from a larger number of suppliers.

### **Section 4.3 Review – Delivery Terms Agreement Model Creation Plan**

Concerning logistics service contracts overview by Forslund (2009), the author observes that only some hundreds of purchase transactions have been recorded in Aventura's ERP systems so far. Due to the restricted amount of data, there is no benefit in employing fuzzy logic model.

In response to Katok, et al.'s (2008) inventory SLA as coordination mechanisms, the author concluded:

- Shorter review periods result in great inventory levels and lower order volumes are already in place.
- Shorter review periods which result in improving supplier performance, since suppliers are able to respond more promptly to demand fluctuations are already in place through agile practices.
- Supply chain bullwhip effect which initiates small spikes in demand are reduced by shorter review periods.

While assessing Christopher & Towill's (2001) supply chain strategies and execution model, the objective on obtaining the right product at the right place at the right time when marketplace survival defined by the end customer has already been in place.

While combining lean and agile paradigms according to Christopher & Towill's, (2001), the following has been observed:

o curve approach cannot be implemented to the current manufacturing cause 100 % of Aventura's production is concentrated within one line, exceptional surge and test samples when a controlled production dispersity is in effect. ation of base and surge demands model by intelligent schedule switching has pted for enhancing supply chain. The base demand the current procurement ich is forecasted from past history through lean procedure. Surge demand is o near the market (or rather on availability regardless the cost).

The respondent's anecdotes have been translated to English and tailored to serve the purpose of academic literature reporting. A copy of this field note has been sent to the respondent 19.03.2023 to ensure the document's credibility.

**Raw Field Notes: FG Feedback Validation on the Proposed Action Plan**

<b>Presentation participants</b>	Jan Sjöblom, CEO of Aventura Oy Timo Markkula, MSc., Senior partner (Aventura Oy’s CEO 2004 – 2021)
<b>Place</b>	Aventura’s meeting room
<b>Time</b>	23.03.2023 14:00 – 15:00
<b>Duration</b>	1 hour
<b>Language</b>	Presentation of English materials and discussions mostly in Finnish.
<b>Setting</b>	FG live presentation
<b>Atmosphere</b>	Time constraint and thorough focus on the entire thesis project
<b>Raw notes</b>	<p>Some of the following raw note anecdotes might include the author’s views and findings in order to assist the reporting flow.</p> <p>In order to assist the information flow and support the information gathering credibility for the thesis project, the author presented the topic in its entirety from the introduction to the action plan proposals at hand.</p> <p>Upon viewing the introductory presentation slide related to Section 1, the CEO strongly suggested that PIV (personal identity verification) to be removed from PKI’s definition. The definition of PKI other than abbreviation is not mentioned in Section 1 of this study. This appendix documents the first time PIV abbreviation appears in the thesis study and by the CEO’s recommendation, the business challenge has been rephrased as: <i>“Global chip shortage has a negative impact on PKI providers (cryptographic keys to perform digital signing)”</i>.</p> <p>Upon viewing the procurement process map, the Senior Partner asserted that the demand forecast analysis is worth the investment. The author responded that it is not a part of the current thesis study scope due to time constraint. The forecast analysis categorized in Table 5 of Section 3.6 will be featured as a part of Section 7.2 Recommendation for Potential Implementation Plan, which will hopefully pave opportunity within the company to conduct a thesis study in respective fields of expertise.</p> <p>The third encountered challenge which states no record on total rejected preforms from each production log (manual Inventory subtraction) as presented in Table 4 of Section 3.5, is determined to be small in quantity according to the Senior Partner. The parties involved agreed that the actual stock revelation may surprise the annual inventory report or on a worst-case scenario, an order’s lead time proposal at a later quarter.</p> <p><b>Section 5.2 Review – Framework for Supplier Relationship Management</b></p> <p>The CEO validated the SRM framework model and further added that there seems to be no commentary on the suggested model.</p> <p>As previously reported in Appendix 5 concerning SRM phase model by Moeller, et al. (2006), the Senior Partner further added that the should have expectation of 1 % annual maximum defect rate concerns mainly dual</p>

interface cards, because 90% of the defects is due to the construction of the antenna prior to contact chip embedment.

### **Section 5.3 Review – Supply Base Diversification**

Concerning Miocevic & Crnjak-Karanovic's (2012) must have supply chain alignment within ERP to monitor SCO, the Senior Partner added *taloushallinto's* built-in reminder is fully functional and has already been implemented for quite a long time. The author added that the initial proposal stage comprises the embedded advantages of the current procurement process as presented in

Table 1 – Data collection plan.

The first should-have aspect under inquiry was employing up to 4 alternative suppliers for the same component as suggested by Do's (2022) guidelines to alleviate the pre-disruption phase of the shortage. The CEO pointed out that the chips come from NXP with four wafer fabrication facilities found in Austin, Texas, Arizona, the Netherlands, and Singapore (NXP Semiconductors, 2023). The CEO further suggested that module reservation might possibly be negotiated through NXP's representatives with whom Aventura is in direct contact with.

As pointed out by the Senior Partner, the last should-have proposal and Section 3.4.1 Manageable with a Smaller Storage Space have been rephrased to:

*Stock value optimization to lessen the risk of obsolete asset which cuts profit margin.*

Obsolete asset and lowered profit margin are more conclusive ripple effects to the capital being tied up in inventory.

Regarding the could-have proposal on "Demand management: Identify which customers require the items first (contract and value prioritized)" according to Do's (2022) guidelines to alleviate the during and post-disruption shortage phase, the Senior Partner stated that the practice has been done although not yet documented. The respondent emphasized the importance of direct communication with the customers, which could provide a demand forecast adjusted according to the current market evaluation.

The Senior Partner further commented that naturally similar approach is not implementable to Aventura's webshop where the online ordering system eradicates the needs of direct customer communication, and the purchase volume tends to be at a much lower scale compared to direct request from the sales representative. Pertaining to Christopher & Towill's (2001) separation of base and surge demand concept in Section 4.3.3, intelligent schedule switching of base and surge demands have been observed in Aventura's production site where the base demand is forecasted from past history and is met through classic lean procedures; and the surge demand is provided through flexible procedures.

	<p><b>Section 5.4 Review – Delivery Terms Agreement</b></p> <p>The Senior Partner suggested that the final proposal could alternately be identified as adaptive inventory model or agile inventory management. The author decided to retain the title of Section 5.4 as is, because the literature materials presented in 4.3 contain practical ideas that could be implemented to delivery terms agreement model creation.</p>
<p><b>Analytical observations</b></p>	<p>The interview was initially booked for 45 minutes, but the meeting was unintentionally stretched to 1 hour due to the stronger focus on the leading sections before the initial proposal concerning refurbished supplier coordination practices.</p> <p>According to the CEO, the customer’s actions of “requesting offer to sales” and “issuing an official PO” as a starting point of Figure 4 – Procurement process map should be combined as one starting point as it could be perceived as misleading. The author stated that upon the customer’s initial offer request, the amount of items issued in the official PO might be contributed by factors supplied by the offer such as price tier, availability, compatibility, and lead time (whether partial or complete delivery).</p> <p><b>Section 5.4 Review – Delivery Terms Agreement</b></p> <p>Upon reviewing the last could-have proposal regarding “the standard capacitance and pantone colour profile resemblance have yet to be defined in more detail” as initially recommended by the Senior Partner in Appendix 5, the respondent hinted that Aventura Oy’s (2022) quality handbook could be improved based on the proposal but at the same time pondered on the implementation practices. The author suggested pantone colour matching tools commercially available on standard mobile platforms. Bearing in mind that the sample has to already be on a physically printed format, hence the application could suggest results based on the closest pantone colour bridge coated profile and calculate the percentage resemblance between the recommended values to the physical sample.</p> <p>The respondents suggest that the responsibility of meeting the standards specified in each PO befalls upon the supplier. According to Aventura’s Quality handbook v1.6 (2022), in case the quality deviations are not up to Aventura’s and ultimately the customer’s predetermined standards, the customers may negotiate measures depending on the deviation’s severity.</p> <p>Concerning the reading distance measurement standard that also has to be defined as initially recommended by the Senior Partner in Appendix 5,</p> <p>In a parallel-plate capacitor, the reading distance can be calculated according to Equation 3.</p> <p>Equation 3 - Distance measurement of capacitance</p> $d = \frac{\epsilon_0 \epsilon_r A}{C}$



where:

- $d$  indicates the distance between plates in meters.
- $\epsilon_0$  marks the electric constant ( $8,85 \times 10^{-12} \frac{F}{m}$ )
- $\epsilon_r$  indicates the dielectric constant of materials between plates.  $\epsilon_r=1$  for air, where the testing environment always is for Aventura's use case.
- $A$  marks the overlapping area of the two plates in sqm.
- $C$  defines the capacitance in Farads (standard value 17pF or 70pF in RFID modules).

(Järvinen, et al., 2019)

In practice, the physical distance evaluation has been performed upon obtaining RFID articles to verify the agreed specification has been met.

The participants' anecdotes have been translated to English and tailored to serve the purpose of academic literature reporting. A copy of the Master's thesis presentation slides up to Section 5 was sent to the respondents on 23.03.2023 and this field note on 26.03.2023 to ensure the thesis study's credibility.