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The Use of Artificial Intelligence in the Supply Chain Management in Finnish Large Enterprises

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ABSTRACT:
The artificial intelligence (AI) provides a lot of potential to development of supply chain management (SCM). AI can operate on strategical -, tactical -, and operational decision-making levels. Operational levels as forecasting, production and warehouse actions are the most common fields where AI can operate. Aim of increasing SCM value creation via AI is to reach almost perfectly accurate forecasts and decreasing costs of production. Customer needs can be filled with sophisticated tools and companies must consider their next game plan all the time as markets become more competitive. Purpose of artificial intelligence technology is to create solutions for problems and fill missing parts of human-made gaps. Supply chain is one of the most critical function of business that must act straightforwardly and fluently. The aim of this research is to map out possible AI applications and determine maturity level of AI in SCM in large Finnish enterprises. This research is based on quantitative and qualitative analysis which illustrates the use of artificial intelligence in supply chain management. The research shows by measuring maturity - and automation level of artificial intelligence that these are lower than expected. The study cleared out what solutions large enterprises use in their supply chain management and results show that they focus on demand forecasting, optimisation, and preparation. This research found that companies are waiting to implement sophisticated artificial intelligence solutions until their maturity of big data is mature enough. As a discussion, due to companies' uncertainty to lose competitive advantage and low maturity level led to scanty data collection. Suggestion for the future research is to examine this subject area when companies have been confident in implementing advanced AI technological acts in their SCM and AI has become more intelligence.

KEYWORDS: artificial intelligence, supply chains, management, large enterprises, big data, business intelligence

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TIIVISTELMÄ:
Tekoäly (AI) tarjoaa paljon potentiaalia toimitusketjun hallinnan (SCM) kehittämiseen. Tekoäly voi toimia strategisella -, taktisella – ja operatiivisella päätöksentekotasolla. Operatiivisina tasoina ennuste-, tuotanto- ja varastotoiminta ovat yleisimpiä tekoälyä hyödyntäviä toimintoja. Toimitusketjun arvon luominen tekoälyn kautta tapahtuu lähes tarkkojen ennusteiden saavuttamisesta ja tuotantokustannusten alentamisesta. Kehittyneiden työkalujen avulla asiakkaiden kasvavat odotukset on mahdollista toteuttaa ja markkinoiden muuttuessa kilpailukykyisemmiksi, yritysten tulee jatkuvasti miettiä seuraavaa siirtoaan. Tekoälyteknologian tarkoitus on tuoda ratkaisuja muuttuviin ongelmiin ja täydentää puuttuvia osia ihmisten tekemissä virheissä. Toimitusketju on osa yrityksen kriittisimmistä toiminnoista, minkä vuoksi sen tulee toimia virheettömästi ja tuottaa lisäarvoa yritykselle. Tutkimuksen tavoitteena on kartoittaa mahdollisia tekoälysovelluksia ja määrittää tekoälyn kypsyystaso toimitusketjun hallinnassa suomalaisissa suuryrityksissä. Tämä tutkimus perustuu kvantitatiiviseen ja kvalitatiiviseen analyysiin, jotka muodostavat kuvan tekoälyteknologian käytöstä toimitusketjun hallinnassa. Mitattaessa tekoälyn maturiteetti - ja automaatiotasoa tutkimustulokset osoittivat, että nämä olivat alemmalla tasolla kuin oli oletettu. Tutkimus selvitti, mitä ratkaisuja suuryritykset käyttävät toimitusketjun hallinnassa. Tulokset osoittivat, että ne keskittyvät kysynnän ennustamiseen, optimointiin ja valmisteluun. Tutkimuksessa havaittiin, että yritykset odottavat kehittyneempien tekoälytoimintojen toteuttamista, kunnes heidän big datan maturiteettitaso on tarpeeksi kypsä. Pohdintana, tutkimuksen suppea aineistonkeruu saattaa johtua yrityksien epävarmuudesta kilpailukyvyn menettämiseen ja matalasta tekoälyn maturiteettitasosta. Tulevaisuudessa tämän aihealueen tutkiminen on ajankohtaista vasta kun yritykset ovat varmuudella toteuttaneet kehittyneitä tekoälyteknologisia toimintoja toimitusketjun hallinnassaan ja tekoäly on kehittynyt älykkäämmäksi.

AVAINSANAT: tekoäly, toimitusketjut, hallinta, suuryritykset, big data, business intelligence

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Abbreviations

AI	**Artificial Intelligence**
RPA	**Robotic Process Automation**
S&OP	**Sales and Operations Planning**
SC	**Supply Chain**
SCM	**Supply Chain Management**
SCN	**Supply Chain Network**

1 INTRODUCTION

This master's thesis studies utilisation of artificial intelligence in supply chain management. It concentrates on to large Finnish enterprises because with general reasoning, small- and medium-sized enterprises do not have resources to exploit artificial intelligence (AI) in their supply chain management (SCM). The aim of the study is to find observations of applications, solutions, and maturity level. This research paper helps to understand what the maturity level of AI solutions in SCM field is and how they use possible applications. The research uses quantitative and qualitative approaches to achieve this goal.

Ellefsen et al. (2019) stated that even the bigger companies are not able to visualise the opportunities what AI can bring for them. This thesis defines opportunities and challenges to discover the benefits of AI technology and determines possibilities to implement AI in SCM. Used literature and frameworks illustrate understanding of the research basis and make clear journey to examine the research questions.

1.1 Background

AI serves as a key technological driver. It leads toward improved productivity across different sectors but also for new working behaviours, processes, and business models. Finland has a great prerequisite for this. As a nation, the key question is how to exploit advantage of the opportunities brought by digitalisation and AI in creating value and increasing productivity. (ETLA, 2019) Microsoft (2018) stated that for Finland, AI has major importance. Also, Finland has been named as one out of seven which stand out from economical and digital innovation performances.

The reason for this thesis subject is media and its constant highlighting of opportunities in AI. Possibilities to utilise technology in SCM have been topical questions for academicians and researchers. Technology allows to make more sustainable, efficient, productive, and predictable decisions. AI has many opportunities in SCM field, and it could make

perfect sync between supply - and demand planning. It would reduce waste and make production more efficient. Otherwise it could decrease failures and uncertainty.

1.2 Purpose of the Research, Research Objectives and Questions

The purpose of this research is to find out how Finnish large-scale enterprises utilize AI in their supply chain operations. In this time when sustainable development is a topical issue around the world, this research helps to understand current stage of implementation of AI in Finnish large-scale enterprises. Many news, articles and research papers have examined implementation of AI-systems. This research aims to discover what kinds of AI operations Finnish large-scale companies have implemented in their supply chain and what the benefits towards productivity are.

The research focuses to measure and analyse what kinds of AI technologies can implement to supply chain and what is current status in this field. Adoption of AI maturity will be measured and evaluated with the newest analysing theories.

Objectives in this research can be set as below:

1. To identify and analyse possible AI applications in supply chain.
2. Examine current status of AI implementations in supply chain management in Finnish large-scale companies which have implemented some AI technology.
3. Do the research of AI application maturities in supply chain field.
4. To help understand global influence of AI for today’s Finnish business actions.

The research aims to answer the following questions:

1. What kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?
2. What is the adoption level of AI maturity?

1.3 Limitations

Limitations can be divided into three sections. First section is AI technology and its complex nature. It evolves quickly and examination of AI is very difficult to study with comprehensive aspect. This research focuses only on AI technology that is related to SCM operations. Second limitation is company scale. This research focuses only on large-scale enterprises as general reasoning lead to decision that large-scale companies have resources to develop and research newest solutions for SCM. Thus, small- and medium-sized enterprises are not involved. Third is that the study is inductive research. It does not examine all the possible solutions concerning the research questions but forms a generalisation.

1.4 Structure of Thesis

The structure of thesis is a basic form of research. Figure (1) present the structure and flow of the research.

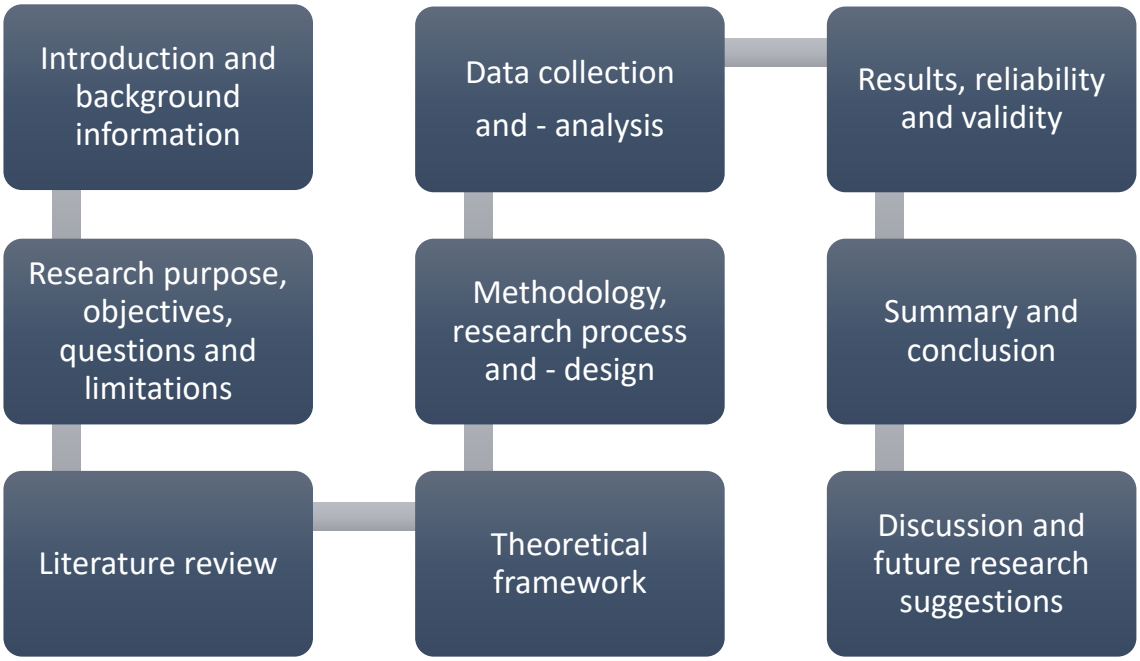

Figure 1. Structure of thesis.

First thesis presents (1) introduction and (1.1) background information of topic area and then (1.2) research purpose, objectives, questions and (1.3) limitations. Second chapter is (2) literature review which consists newest view and previous studies of topic area. Chapter three presents (3) theoretical framework which explains the role of the theory in this research. Chapter four introduces (4 - 4.1) methodologies, (4.2) research process and - design. Then (4.3) data collection and – (4.4) analysis are determined. (5 – 5.1) Results, (5.2) reliability and validity of the research are presented at chapter five. At the end, (6 – 6.2) summary and conclusion consists discussion and future research suggestions.

2 LITERATURE REVIEW

This part of the study presents previous studies and a review of literatures in artificial intelligence and supply chain management (SCM). It aims to give some background information about the concept of topic area. First part consists of a brief background information of SCM. After that reader understands main points of SCM and can focus on results with knowledge. Second part consists of artificial intelligence and its aspects to get general knowledge of it.

The literatures related to SCM were searched by using keywords “supply chain”, “supply chain management” and “operations management”. Search results were assessed by observing newest editions and contents related to the topic area. Literature review concerning SCM will be described briefly as information related to SCM is easily available. Operations Management in the Supply Chain from Schroeder & Goldstein (2016) and Operations and Supply Chain Management from Jacobs & Chase (2018) books consists a lot of information for the literature part. Also, the decision levels of SCM are considered by using available research papers and studies of it. Performed research was Krichen & Ben´s (2016) study called Supply Chain Management and its Applications in Computer Science. This research gives computational perspective for this study to examine decision levels in SCM. Another used research by Wassim et al. (2012) gives figurative understanding for decision levels and aspects in general for the research.

The literatures related to artificial intelligence in SCM were searched using keywords and phrases which were relevant to the topic. For example, “artificial intelligence in supply chain management”. The research must point out that the assessment of AI capability evaluates all the results in the same way. With this search the result was publication called “Artificial intelligence in supply chain management: theory and applications” written by Min (2010). Objectives of Min’s research is to identify sub-fields of AI technology and consider the most suitable solutions for SCM to improve efficiency. It also summarises current trends and explores potential applications to SCM. Even though the article is published ten years ago, it gives a good base for this research and valuable information

about applications that can be used in SCM. Because theory and applications of AI apply mainly same base today, this research can be used. Integration between AI and SCM are examined in Min's study and it gives valuable perspective for this research.

Many articles, studies and research papers were examined during this literature review process and comparison between valuable and invaluable information were considered by following; quality, relevancy, date of research, researcher background, similarity with the topic area, logicality, and many other aspects. The main literatures were examined, and criticality towards chosen sources required that the source is new, informative, reliable, and its quality is excellent.

Publication	Written by	Published
Operations and Supply Chain Management. 15th edition.	**Jacobs, R., & Chase, R.**	**2018**
Supply chain management and its applications in computer science.	**Krichen, S., & Ben, J. S.**	**2016**
Operations Management in the Supply Chain: Decisions and Cases. 7th edition.	**Schroeder, R., & Goldstein, S.**	**2016**
Artificial intelligence in supply chain management: Theory and applications.	**Min, H.**	**2010**
Optimization/simulation-based framework for the evaluation of supply chain management policies in the forest product industry.	**Wassim, J. et al.**	**2012**
Artificial intelligence: 101 things you must know today about our future.	**Rouhiainen, L.**	**2018**
Artificial intelligence: next step in supply chain mgmt	Sanchez, E.	2002
Editorial note for the special issue on 'Artificial Intelligence Techniques for Supply Chain Management'	Jain, V.	2009

Table 1. Literature source criticality.

All the bolded publications will be considered in this research and not bolded are abandoned due to source criticality. Research by Sanchez, E. is not the newest information for this research and publication by Jain, V. is only editorial note which is not informative and does not give comprehensive understanding for this research. Chosen literatures turned out to be the latest publications of current field forming the base for this thesis. Other available sources will be used to fulfil missing perspective for a specific section.

2.1 An Overview of Supply Chain Management

Successful firms have made a focused and clear idea of value creation, no matter if it is related from high-end products to custom-tailored services or generic and cheap commodities. However, how good your marketing is, no one may buy it if the product or service cannot be delivered to the consumer at an acceptable cost. (Jacobs & Chase, 2018)

Many companies should improve their SCM because their products spend time in inventories at least six months to a year or more. Since the products spend a lot of time in inventory, there is a huge opportunity to increase flexibility, reduce costs, make better deliveries, reduce cycle time, and lead to a more corresponding reduction in inventory. Several companies have improved their supply chain with internal operations. They have recognised that it has a relation to external customers and suppliers and with it they can gain further improvements in operations. (Schroeder & Goldstein, 2016)

Krichen & Ben (2016) described SCM to the decision-making process which manages different activities that create beneficial profits to suppliers, retailers, and customers. The efficient planning of activities can be cost-effective for production, sourcing, product development, logistical solution and for all flows that is linked between these activities. It can also be a process which optimises a set of decisions. The process generates profitable solutions to provide efficient plans for acting on numerous levels while considering all decision-making standpoints. (Krichen & Ben, 2016) Jacobs & Chase (2018) advise that operations and SCM is critical for everyone to learn, no matter what your major is. They

stated that even if your interest is in financial field, convert all values to the currency of your choice and after that, you will understand that it is about currency moving, storing, and exchanging the value.

SCM is a vital aspect of making-business today. For reader to understand what supply chain is, the research provides a formal definition of supply chain. There is a set of entities and relationships which are called supply network. In this supply network information and material flows are called downstream and upstream. Downstream goes towards the customer and upstream towards to the first supplier. (Schroeder & Goldstein, 2016)

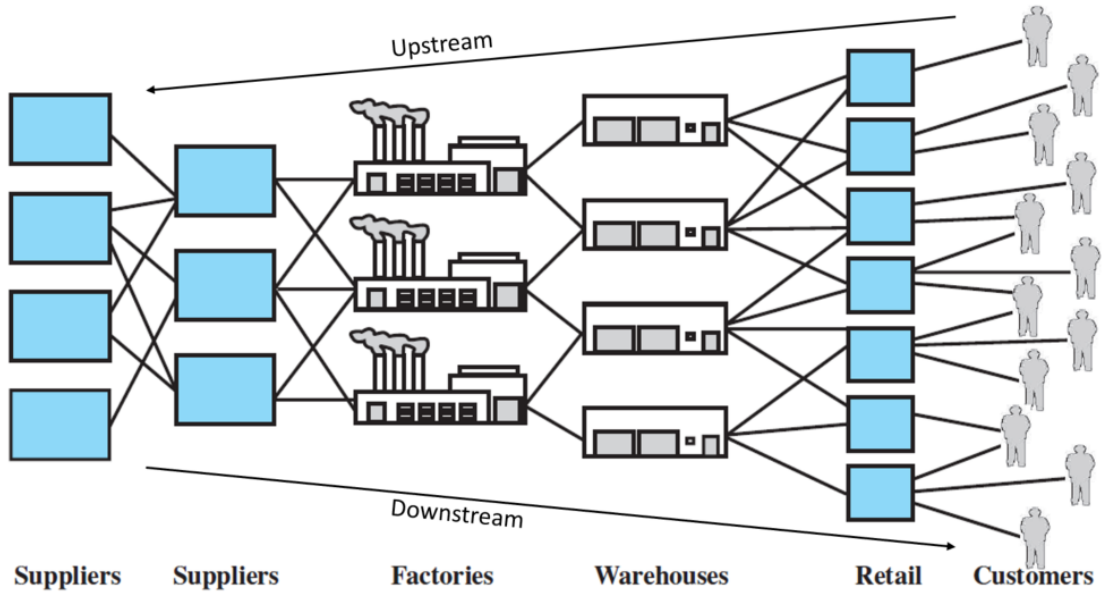

Figure 2. Supply chain overview (adapted from Schroeder & Goldstein, 2016).

Downstream from the supplier to the customer consists of materials and requisite information, for example, usage instructions, invoices, inventory levels etc. and it flows until materials are transformed to the final product and sold to the end-customer. Upstream from the customer to the first supplier consists returned materials like defective units, customer returns, recyclables etc. and requisite information like forecasts and demands.

With information of forecasts and demands, it is easier for suppliers to plan capacity and inventory level. (Schroeder & Goldstein, 2016)

Supply Chain Decision Levels

Supply chain includes three planning decision levels in the SCM. Those are strategic, tactical, and operational levels. Difference between these levels is the time frame of the related decisions (Wassim et al., 2012).

Strategic decisions are usually made for a long-time period. At the strategic level, decisions must be made considering a location of facilities where to operate, production technologies and then select the portfolio of suppliers to employ in the supply network. (Krichen & Ben, 2016; Wassim et al., 2012) Information and technology infrastructure are related to strategic decisions because that supports the SC operations and strategic partnerships (Krichen & Ben, 2016). Thus, strategic decisions define the supply network through which assembly, manufacture, and distribution to serve the marketplace (Wassim et al., 2012).

After strategic decision level is followed by tactical decision level. Tactical level decisions are medium-term decisions and length is from couple of months to one year (Wassim et al. 2012). At this point, the supply network is managed to respond, on a tactical and operational basis. These decisions based on customers' demands and it goes through control and planning processes. (Krichen & Ben, 2016) Production plan is usually provided in this level which is established based on forecasts (Wassim et al., 2012). Strategic level consists of decisions which are planning decisions aimed at to capacity and balancing charge. These actions include the production, inventory, sourcing contracts and purchasing decisions. (Krichen & Ben, 2016)

When tactical level is designed, operational level addresses issues such as detailed scheduling, inventory deployment and shipments (Krichen & Ben, 2016). Operational

level operates with the circumstances which are made at the strategic and tactical levels. In other words, it provides a daily functioning and efficient organisation. (Wassim et al., 2012) Operational level supposes to do short-time decisions, such as ordering, transportation and production. Operational level can be called as “flow management”. (Krichen & Ben, 2016)

Following figure (Figure 3) show the time frame of planning levels.

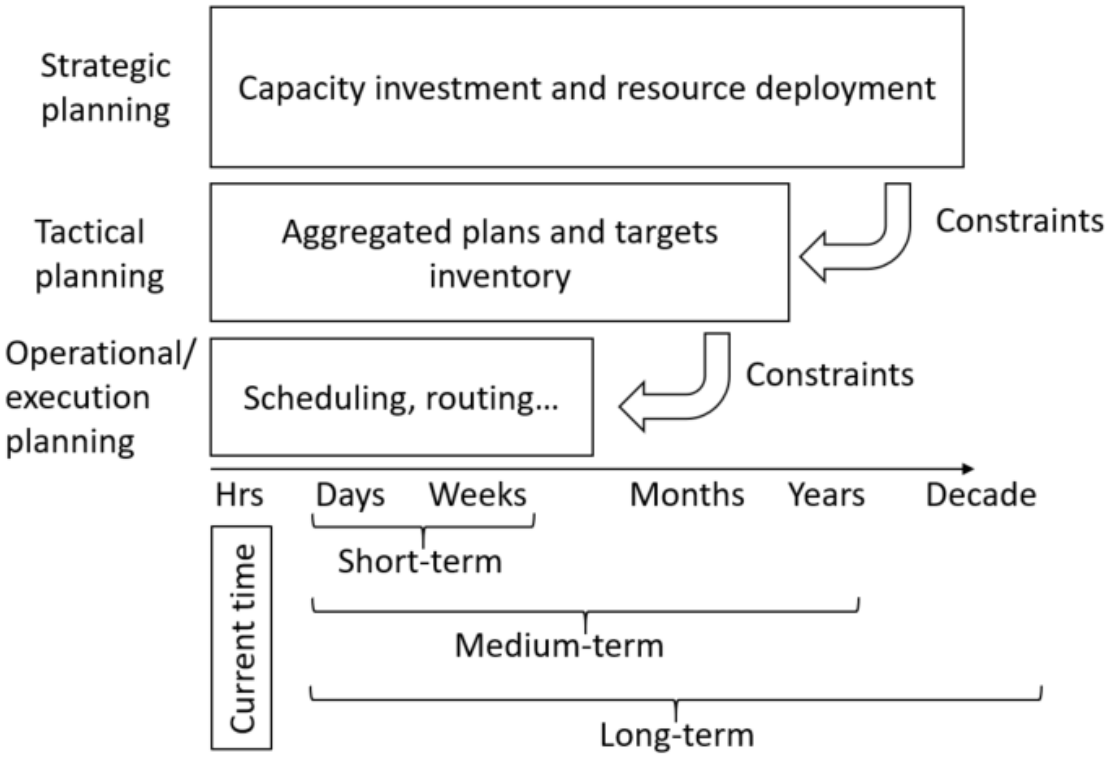

Figure 3. Strategic, tactical, and operational planning levels (adapted from Wassim et al., 2012).

2.2 An Overview of Artificial Intelligence

Recent years have shown that artificial intelligence has raised curiosity in SCM area. Since the late 1970’s, development of AI has focused on to increase business productivity and ability to understand phenomena and patterns of business. Time-consuming and routine work tasks can be done by robotic process and machine learning as algorithms learn from data and analytics. With these, customer relationship management solutions

reveal information for company to serve a customer with better knowledge. (Soleimani, 2018) According Bughin et al. (2017) report for McKinsey Global Institute, companies invested $26-$39 billion on AI in 2016 and high-tech companies used 90 percent of their investment in AI in the research and development (R&D) and deployment sector and 10 percent to AI acquisitions.

AI is defined as computers' ability to solve problems independently when they have not been programmed explicitly to do particular task. The modern AI platforms have ability to gather information from surroundings. This kind of AI is made to use logicality and probability to choose and act within the highest likelihood of success. AI uses big-data sets, objects and sounds to act intelligently and recognise with distinguished precision. (Dash et al., 2019)

AI gives ability for machines to feel environment in the same way as human being. This means completely new way for businesses to interact with their customers and offer them more holistic experiences such as intelligent products, service, and automated processes. AI is the most powerful technology of mankind. In the most basic form, AI exploits data for calculations or algorithms and makes decisions or predictions. This basic form runs into difficulties when calculating algorithms and calculations are more complex or user cannot describe the rules. In modern AI, for example, face recognition from different angles replicates this by using neural networks. Instead that human creates the rules for algorithms and calculations, machines program the rules themselves. (Marr, 2019, pp. 1-4)

As a conclusion, definition of AI can be explained as machines that use big data to compare it to algorithms and calculations and make predictions of what is the most successful result. It can be used in many ways and today's AI technology is capable to do individual, holistic and complex decisions considering many aspects.

According to AI research commissioned by Microsoft (2018), over 50% of Finnish companies had already implemented AI in production and creating new insights. This research consists executive level professionals from 22 companies and purpose of the research to map out preparedness of implementation in AI and vision of companies' AI possibilities. Also, the research explores how companies see AI technology to exploit business actions in four dimensions. Those dimensions are customer involvement, productivity of workers, intensification of operations and renewal of products. (Microsoft, 2018)

Finland has an advantage when comparing to other countries in Europe but there is a huge gap between expectations and possible benefits. Only 14 percent of Finnish companies exploit AI in many different ways in business processes and supporting work tasks. Summing up Microsofts' findings, Finnish businesses are in experimentation phase in implementation of AI. One of research question was "To what extent have you implemented Artificial Intelligence in the following company functions?". Functional AI-heatmap shows that many companies have implementations in logistics, but end-to-end supply chain planning is classified as neutral focus area which means that only at "planned" level. (Microsoft, 2018)

Machine Learning

Basic structure of machine learning consists of deep learning where outcome is artificial intelligence. Machine learning is one of the main approaches to artificial intelligence where machine learns without being specifically programmed. (Rouhiainen, 2019)

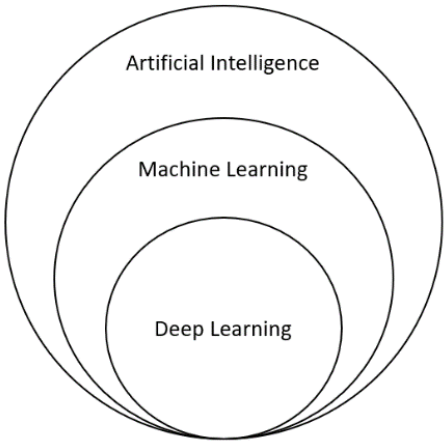

Figure 4. Basic structure of artificial intelligence (adapted from Rouhiainen, 2019).

Machine learning is created for computers with the ability to learn without the platform was especially programmed in specific way. Thus, it examines possible solutions and ways in which the computer can solve the problem by using available data (Min, 2010). Machine learning can be defined into three learning categories which are supervised, unsupervised and reinforcement. Supervised learning uses algorithms to use data, which is already organised and labelled, and in this method human input is required to give feedback for the system in this method. Unsupervised learning, where data is not labelled or organised, implements algorithms but it discovers relationships in the data without human intervention. In reinforcement learning, algorithms are tough and able to learn from experience. (Rouhiainen, 2019) Machine learning techniques are trying to copy human behaviours based on experience and knowledge. In practical point of view, it can be a useful tool to understand SC partner motivation behind co-operation and strengthen partnership through organisational process. Machine learning is recently used method to forecast the inaccurate demand information (bullwhip effect) occurred because of lack of co-operation. (Min, 2010)

Machine learning process contains five steps for being able to successfully learn and evaluate specific function. First step is data order, where the data is transformed from sorted to random data. Second step is to choose a model, where algorithm should be chosen. Thirdly, the model must be trained, and the algorithm will calculate the weights

of each factor. Fourth step is to evaluate the model. In this step, algorithms are measured and evaluated between results and the real-world situation. Last step is to adjust the parameters for learning and the process as fluent as possible. Machine learning is used in many ways and few examples are predictive maintenance, recruiting employees, increasing customer experience, finance, and customer service. (Taulli, 2019)

Deep learning

Deep learning is a sub-field of machine learning and it is one of the most growing applications of AI. It is capable to learn from unsupervised data that is unlabelled and unstructured. It is used to understand phenomena and problems which are too complex or problematic to solve by human. Normally, it involves significant amount of data. Deep learning uses neural network *(defined in neural network chapter)* to recognise complex relationships and patterns in data. It requires a huge dataset and computational power. Deep learning is currently used in, for example, vehicle identification, computer vision, natural language processing and speech recognition. (Rouhiainen, 2019)

Neural Network

Neural network is designed in the same way as living organ's brain cells function. It can learn from abstract information, recognise patterns, process ambiguous, gain experience, distinguish features and cluster objects. Neural network consists of nodes which are connected to each other with links and links storage long-term memory. Information links with the primary intention can be strengthen or weakening nodes depending on links weight. The learning process includes placing of links depending on the weight of links. Neural network is supposed to successfully answer for wishes of user by using data models. Also, it is supposed to learn hidden interrelationships among the data. (Min, 2010)

Expert System

Expert systems can copy human cognitive skills. It can execute problem-solving, language understanding, visual perception and perform problem area with significant amount of human knowledge. Expert systems consist of four components. Those are knowledge base, inference engine, justifier/scheduler, and user interface. Knowledge base is based on acquired rules and knowledge of human expertise. Inference engine is called “the brain of the expert system”. It is cluster of problem-solving programs purpose of which is to search, and conclude the rules based on knowledge base. The justifier tells why and how the expert end up with that specific solution and scheduler is set up to monitor and manage the sequencing rules. User interface purpose is to make interaction between user and platform as fluent as possible with user queries. (Min, 2010)

However, as expert system gets larger it causes challenges to manage data and whole expert system. Results are usually more incorrect than successful outcomes and when the expert system was tested it revealed to be a complex process. Also, it turned out that system did not learn over time and by the late 1980’s, business world did not want to develop it anymore. (Taulli, 2019)

Genetic Algorithm

Genetic algorithm method copies the beliefs of natural evolution and gathers rules of natural selection processes. It creates organisms which fit for the surrounding environment. Also, genetic algorithm fits into solving combinatorial optimisation. It formulates a function that can measure specific representative to specific environment. Genetic algorithm consists of five components.

Those five components are:

1. A genetic demonstration of a solution concerning a problem.
2. The way to implement a population.
3. Measurement function, which evaluates the matching of solutions to see do they survive.
4. Genetic operators includes mutation, crossover and reproduction which change genetic composition of offspring.
5. Parameter values which define size of population, crossover rate and mutation rate. (Min, 2010)

Agent-based System

Agent-based system divides the problem to sub-problems and tries to solve those sub-problems to accomplish the whole problem. These sub-problems are called agents where each of agent can use different methodology, knowledge, and resources to accomplish given tasks. Agents are autonomous but they can cooperate with other agents while chasing individual goals. (Min, 2010)

2.3 An Overview of Artificial Intelligence in Supply Chain Management

According to Michael Galuzzi, business strategist for SCM and additive manufacturing at the NASA Swamp Works Lab at Kennedy Space Center, says

"The future will be written by organizations that develop capabilities for sourcing and distributing relevant data content at every link and life cycle of the value chain, from development of new products and services to delivery—even when the consumers are located on Mars" (Barlow, 2015).

Increasing competitiveness, higher supply risk and demand uncertainty forces ability of integration and orchestration of the end-to-end process. Sourcing components and materials and converting them into finished goods and further on delivery to customers.

Thus, leading-edge organisations share their real-time information with SC partners and enrich their information sources. (Min, 2010)

According Dash et al. (2019) in their research "Application of Artificial Intelligence in Automation of Supply Chain Management", they have classified AI helping businesses in four areas. These four value creation areas are vital for gaining competitive advantage.

Those areas consist aspects as:

1. Reach almost 100% accurate forecasts including customer demanding and projection.
2. Gain production with decreasing costs and increase quality with optimising their R&D.
3. Helping in promotion as defining the price, demography, recognising target customers and create the right message etc.
4. Provide better experience for customers. (Dash et al., 2019)

SCM is one of the most competitive areas in business which emphasize the interaction with different sectors, marketing, production, and logistics. In recent years, AI has been proven to be vital aspect for SCM. Modern machines with AI platforms can gather information from available data and use it to choose most probable and logical act with likelihood success. (Dash et al., 2019)

According Min's (2010) research, AI integration to SCM can be divided into three sections. Expert systems contain inventory planning, make-or-buy decision, and supplier selection. Genetic algorithm containing network design and agent-based systems takes over demand planning, forecasting, customer relationship management, negotiations, and order picking. AI is presented as a useful decision tool to help companies connect with customers, suppliers, and network partners to change informational knowledge. (Min, 2010) Especially areas where forecasting is highly needed such as replenishment, the use of AI is scientifically and practically highly developed. The pioneers of AI have integrated

broad spectrum of applications in their everyday businesses, while the competitors invest strongly in new ideas. However, some of the companies does not actively use or do any effort to adopt such technology. (Weber & Schütte, 2019)

Forecast Demand and Optimisation

Trying to keep supply and demand in balance has always been a problem for organisations. Forecasting and anticipating demand are not a new thing with computer-based programs but better forecasting is needed for production and supply chain. Analysing data automatically with AI platform produce more accurate and reliable demand forecasts. With more accurate forecasting, businesses can minimize the waste and optimise their sourcing, reduce costs related to supply chain actions. As AI recognises trends and patterns of business, it helps to design better manufacturing and retailing strategies. Weather-related solutions (e.g. DeepMind developed by Google) predicts the best supply and demand variation considering local weather forecast on the day of delivery. AI solution considers prices, campaigns, local weather forecasts, historical data of sales and many more. (Dash et al., 2019)

Production

To make better optimisation of processes and assets, AI has made a significant impact in production. AI can organise and design the best solutions of robots and people to make reliable and high-quality production. Also, prevention of downtime for maintenance can be predicted by AI. Automation, robots, and robotic solutions led to advanced technology implementations which can recognise objects and materials with camera-equipped robots and taught to recognise empty shelf place. This dramatically increases the speed of picking objects compared to conventional methods. (Dash et al., 2019)

Inventory

Jacobs and Chase (2018, pp. 515-516) describes that logistics visionaries have talked many years that the role of inventory in modern supply chain will be eliminated or at least affect radically. In the future, inventories would not need any buffer because supply and demand will be in a perfect sync. This means dramatical reduction of logistical costs. Most companies have not honed their technologies and networks to the point where they could abandon one's principles, inventory. (Jacobs & Chase, 2018)

For end consumers, inventory might be the most visible action of SCM. The most important operations management's responsibility is inventory management because inventory ties up capital and affects to the delivery of goods to customers. Inventory management affects to many business functions. (Schroeder & Goldstein, 2016)

2.4 Challenges and Opportunities to Implement AI in SCM

Challenges

AI as robots, IoT (Internet of Things) or supporting decision-making as intelligent agents can enrich human experience. Otherwise, it can fail and cause physical injuries, financial loss, and more subtle harms such as instantiating human bias and damaging individual dignity. These failures can cause unreliability because strange, unpredictable, and new dangers can lead to general inconvenience and abandoning AI. It is deeply transformative technology which is fast developed omnipresent in everyone's life. AI approach must be holistic, and it must reflect to many ways which AI can fail. (Mannes, 2020) Microsoft (2018) stated in their research that data reliability is top of challenges of AI. The data and technology are not mature yet enough to implement AI solutions.

Challenges of AI-tools integration in SCM are currently following:

- User has no free will and that is why it leads strongly to computer program which can cause wrong decisions if it is programmed wrongly.
- Implementations are not easy to establish because they are esoteric and for ordinary decision-makers hard to follow.
- Cross-border and cross-functional SC decision environments where AI may not be capable to function properly which is due to its knowledge acquisition bottlenecks. (Min, 2010)

According to The World Economic Forum (2016), optimising machines to serve peoples' needs with AI has attracted attention to the ethical questions and risk assessments which are related to AI:

- Does AI increase unemployment?
- Does AI lead to bigger gap between wealthy and poor people?
- Does AI and robots influence in peoples' behaviour and intercourse?
- How can we get protection against mistakes?
- Do machines learn to be biased?
- How do we guard AI systems from adversaries?
- Can AI occur negative side effects?
- How do we control a complex intelligent system?
- How the humane treatment can be defined for AI?

Opportunities

Recent studies have shown that well-structured AI-tools in SCM are limited to tactical and operational problems. Agent-based systems have the most potential in SCM to solve strategic issues in customer relationship management, relationships of outsourcing, B2B negotiations, strategic alliances among SC partners and collaborative demand planning to eliminate bullwhip effect. (Min, 2010)

To understand the drivers of new demand patterns, companies can exploit AI to take over decision-making, routine planning and activities in SC. Demand planning usually suffers of inefficiency when reacting in unpredictable demand patterns. Deep learning automatically recognises patterns from external signals and can distinguishes inappropriate signals to relevant signals. With signals it can fine-tune demand forecasts. (Monahan, S. & Hu, M., 2018)

Advances of AI consist tracking weather, spot market capacity, identify key variables of demand drivers, feedback from product quality, and gather data from production machines to make better planning. Genetic algorithms can identify batches related to SC planning and decision-making cycles. These reroute orders and address near-term supply delays. Identifying batches with genetic algorithms helps to recognise in-house expenses and automate procurement of alternative capacities. (Monahan, S. & Hu, M., 2018)

The solution is not to buy latest planning software from AI-company. AI solution is a holistic ecosystem with the right algorithms, - mix of internal and external data and rights of decisions. Sustain solutions lead to strong end-to-end change management. To achieve successful SC planning, companies must identify new technological solutions that helps them in complex business environment. (Monahan, S. & Hu, M., 2018)

2.5 Summary of Artificial Intelligence in Supply Chain Management

In a planning level, AI concentrates in SCM field to forecasting, demand planning and optimisation. These areas increase customer experience and make better assessments for processes and assets. The most potential areas of AI in SCM can be considered agent-based systems as it can operate in many SCM areas. AI can operate on strategical -, tactical -, and operational decision-making levels, but mostly on operational levels as forecasting, production, and warehouse actions.

Increasing competitiveness, demand uncertainty and higher supply risks make companies invest enormous amounts of money to R&D when modern AI technology is implemented, and they are trying to find best AI solutions for business actions. However, companies should not be blind-folded when investing to AI solutions but consider exactly what serves them in the most sustainable and comprehensive way. Also, they must think what challenges AI may bring for the company in ethical and data maturity point of view.

SCM value creation via AI are to reach almost perfectly accurate forecasts and decreasing costs of production. It also increases quality by optimising their R&D and helps recognise target customers and provide better customer experience. With accurate forecasts, companies can minimize the waste and thus be more sustainable. They also can reduce costs and optimise sourcing. Weather-related solutions can predict the best supply and demand variation based on local weather forecasts. This solution could be great key for retail stores to optimise their sales e.g. in hot summer days.

In production, AI can predict maintenance downtime and make production more reliable and high-quality. Camera-equipped robots can recognise objects and materials and increase speed of picking. AI can make remarkable impact for inventories when supply and demand are being in perfect sync. This leads to decreasing capacity of inventories and satisfies customer needs rapidly.

3 THEORETICAL FRAMEWORK OF ARTIFICIAL INTELLIGENCE IN SUPPLY CHAIN MANAGEMENT

This chapter formulates the conceptual framework and contains key concepts of topic area and available theories for assessment of AI in SCM and evaluate maturity level. The chapter contains theories to measure the suitability of AI for SCM. The research questions are “what kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?” and “what is the adoption level of AI maturity?”. A theoretical framework analyses key concepts of research questions, theories, and models. After analysing, this chapter proves the validations of chosen theories and models. Observations and relations between theory and the subject area will be explained.

The main framework has been used in Ellefsen et al. (2019) research of “Striving for excellence in AI implementation: AI maturity model framework and preliminary research results” and it combines AI maturity levels between logistical maturity. This framework precisely gives a great base for this research and evaluating different maturity levels on case companies in their logistical actions. It has been published in Scientific Journal of Logistics in 2019. Evaluating maturity levels in logistical operations gives theoretical framework for this research and makes research valid.

The peripheral framework to analyse current maturity status of AI implementations is chosen from Vesset et al. (2018) study “Artificial Intelligence-Based Automation Evolution Framework”. The article cost a lot of money and this research is not funded, thus, the blog post of the article by Dan Vesset will be used as the peripheral framework. The blog post is written by Dan Vesset who was main writer of the article.

This research focus on follow inductive logic which is form of reasoning and starts from single observation sets. Combining observation sets, the logic leads to the most common claims. Analysis units are not predetermined, and structure of theory is built based on data. Premise of inductive approach is not to test hypothesis or theory and researcher

does not choose what is important. Data orientation requires self-discipline in keeping with the data, eliminating preconceptions and being systematic. Data oriented research might seem contingent and intuitive, but the researcher must reflect own actions and assess validity of the research. With qualifications the reader gets information of the research background and its validations during the research. (Saaranen-Kauppinen & Puusniekka, 2006)

3.1 The Maturity Models of Artificial Intelligence

The key concept, AI is determined in the literature review part with all the possible applications it consists, but the assessment of AI maturity in SCM is more complex thing. This research does not focus on measuring AI from computer-science point of view but instead it states how mature and advanced AI implementations are now.

According Ellefsen et al. (2019) maturity model can be described as “the state of being complete, perfect or ready”. They relate the maturity to state of growth and excellence levels where the process perform maturity which can be transformed to growing, improvements and excellences. Technological readiness is described as how ready or mature is the technology, which will be applied. In its simplicity, readiness means is the technology ready or not ready. Readiness is associated with maturity but difference between readiness and maturity is that readiness assessment performs before maturity process and maturity assessment objective is to capture the as-it-is state during the maturity process. (Ellefsen et al. 2019.)

Majority of chosen maturity models have been developed by research centers and commercial entities, for example McKinsey, IBM, Intel, and Accenture. Authors of this model found five core pillars which create critical base for AI-driven communication service providers. Core pillars are strategy, organisation, data, technology, and operations. These core pillars are identified to four core phases, which are AI Novice, AI Ready, AI Proficient and AI Advanced. (Ellefsen et al. 2019.)

AI Novice	AI Ready	AI Proficient	AI Advanced
Novice phase has not taken any proactive steps towards AI or is at assessment mode.	Ready phase has sufficiently prepared in terms of strategy, data availability and organisational setup to implement AI.	Proficient phase has a reasonable understanding and experience of AI and knowledge how to move forward, but still has gaps and limitations.	Advanced phase has expertise and experience of AI and it has been proved in across different cases.

Table 2. AI maturity model (adapted from Ellefsen et al. 2019).

Aforementioned model investigates maturity levels of AI in logistics companies and combines results with Logistics 4.0 maturity model (Ellefsen et al. 2019). Term Logistics 4.0 mean evolution of logistics and this phase of evolution ties technology intensively into logistical operations (Poli, Saviani & Júnior. 2018). Combinations of AI and Logistics 4.0 maturity levels can be evaluated between digitalisation, robotics, autonomy, intelligence, automation, and self-awareness in companies. With evaluating these combinations, AI readiness levels will be recognised. This evaluating process helps to justify or fail hypothesis that companies are far away from effectively AI solutions applied in logistical solutions in practice. (Ellefsen et al. 2019.)

Connections between the study “Striving for Excellence in AI Implementation: AI Maturity Model Framework and Preliminary Research Results” by Ellefsen et al. and this research are remarkable. Ellefsen et al. examined maturity of AI implementations in Norway and Poland in a multi-case study. This research focuses on Finnish large-scale companies with implementations and tries to find out how they have implemented AI technology in their SCM. This model gives good base for research to find out what stage the company is in implementing AI technology.

Vesset et al. (2018) made a framework which helps to plan decisions related to AI-based automation. AI-based automation and technology are vital to evaluate between a human and machine interaction across five levels to understand who analyses the data, who makes decisions based on the analysed data and who makes actions based on the decisions. (Vesset, 2019.) The five levels of AI-based automation are determined in following figure.

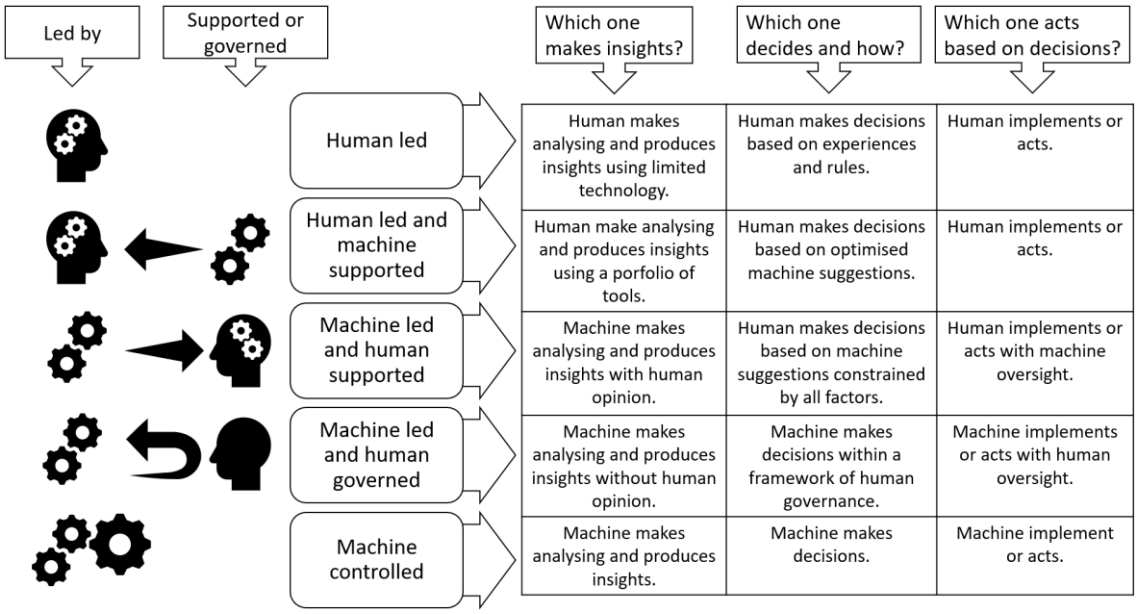

Figure 5. Levels of AI-based automation (adapted from Vesset, 2019).

According to Yablonsky (2019), who used the framework in his research "Multidimensional Data-Driven Artificial Intelligence Innovation", figure (5) helps organisations to transform initiatives and thus concern steps they need to take a move to next advanced stage of maturity. Thus, organisations must concentrate on interaction between humans and machines and understand who analyses the data, who implement the results of the analysis and who acts when decisions are established.

Difference between Vesset et al. (2018) and Ellefsen et al. (2019) frameworks is implementation levels and machine versus human leading solutions. Research by Ellefsen et al. (2019) gives reliable point of view for the phases of AI maturity levels. This framework

answers for the research question “what kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?”. The levels in Supply Chain Decisions (2.1.1.) are strategical, tactical, and operational levels and developing this framework, this research is aiming to the stage of implementation and maturity of AI. As well this framework answers to the research questions. Research by Vesset et al. (2018) gives aspect of how companies use their AI technology and which stage it is now. It considers the stage of human or machine leading. With this framework, this research can answer for the research question “What is the adoption level of AI maturity?”. This framework supports the framework from Ellefsen et al. (2019).

Enterprise type classification bases on recommendation of EU commission. Every Finnish company is determined in classes dependent on their number of employees, revenue, balance sheet and group relationship. In large-scale enterprises number of employees are more than 250, revenue is more than 50 million euros and balance sheet is over 43 million euros. (SVT, 2018). These values are considered during the research.

3.2 Development of the Frameworks

By developing Ellefsen et al. (2019) and Vesset et al. (2018) frameworks and combining those into one framework may be the most suitable solution to get results for the companies AI maturity and AI-based automation levels.

Figure (6) combines two frameworks to illustrate AI maturity level and AI-based automation level. This figure will be shown in results section and shows a stage of Finnish large-scale enterprises maturity and adoption levels.

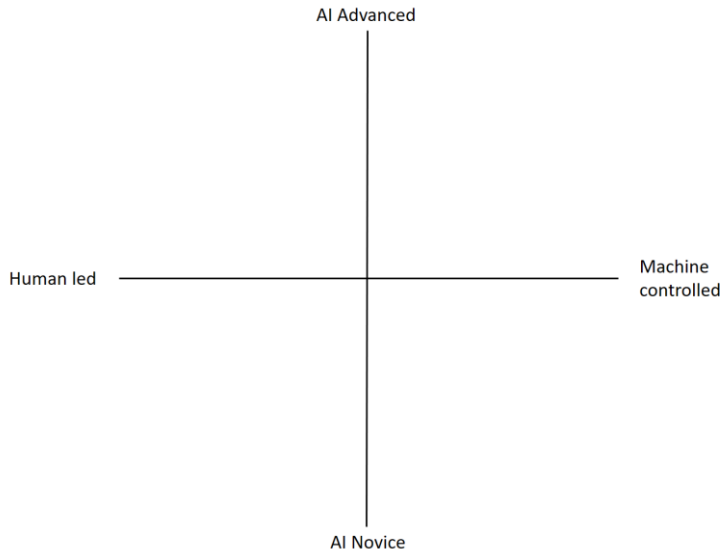

Figure 6. Developed framework for AI maturity model and AI-based automation level (adapted and combined from Ellefsen et al., 2019 and Vesset et al., 2018).

3.3 Development of Survey & Interview Questions

Quantitative part of this research is survey via questionnaire form for the Finnish large-scale companies. According Ellefsen et al. (2019), identifying the maturity levels the survey structure was divided on parts. These parts are basic information, management area, physical process flow, information process flow, additional information. The questions follow the structure of questions which are indicated in the framework.

To identify level of maturity of AI solutions and - implementations the respondents will be asked following questions:

Basic information

- Occupational title.

Management area

- Experience of SCM.
- Experience of AI.

Physical process flow

- Does your company use AI to manage the supply chain?
- Does AI make decisions on behalf of employees?
- What kinds of decisions does AI make in your supply chain?
- How often do you have to monitor decisions made by AI?
- Will you develop supply chain operations by AI in the next five years?
- What kinds of tasks AI is performing?
- At what different stages of the supply chain does the work produced by AI show up?
- What kind of AI do you use to control the supply chain? (e.g. robotics, machine learning, etc.)

Information process flow

- Do you exploit AI across internal borders in a supply chain network?
- Does your system collect big data on supply chain operations? (Big data: large and unsystematic data masses)
- Do you use spreadsheets in supply chain operations to forwarding information (e.g. Microsoft Excel)?

Additional information (opinion-based questions)

- How much would you see AI influencing the flow of information between the supply chain networks?
- How much do you think AI would add value to managing the supply chain?
- Do you think that AI produces transparency to supply chain processes in your company?
- How important do you consider AI in everyday working and when managing the supply chain operations?
- Choose the most appropriate option from your company's AI know-how level of supply chain. (Table 2)

Scope of the questions is to find out today's status of AI maturity in SCM. According to Ellefsen et al. (2019), the research questions are formulated by authors to find out answer for two questions: "(1) Are logistics companies ready to go digital? (2) Are logistics companies ready to become smart and intelligent?". The questions of this research differ from original questions because this research focuses on slightly different research questions. The survey has chronological order related to whether the company uses AI or not.

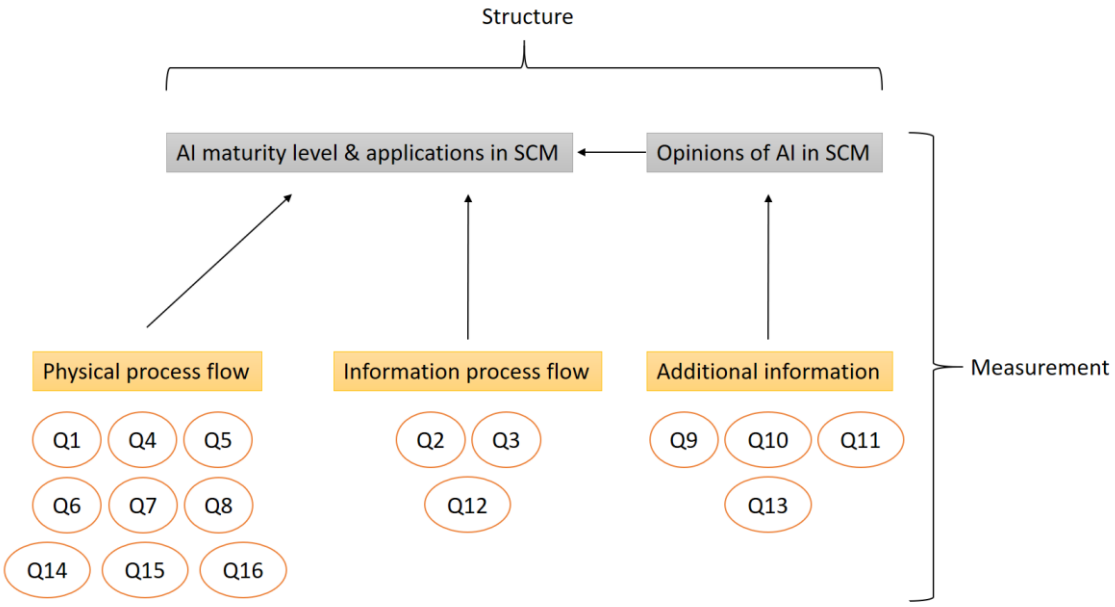

Figure 7. Structure of the Survey.

Interview questions were formed based on survey results and the purpose is to find deeper understanding to definitions which survey presented. Following questions will be asked from respondents.

Basic information

- Occupational title.

Management area

- Experience of SCM.
- Experience of AI.

Physical process flow

- What kind of artificial intelligence you exploit in supply chain management?
- How it accomplishes forecasts and order management? Does the work of artificial intelligence occur anywhere else?
- Does artificial intelligence make decisions behalf of employees and are those strategical-, tactical- or operational decisions and results?
- How often you must monitor the artificial intelligence? Daily, weekly, or how many times?
- Do you have the will to develop it and do you see the potential? And will you develop it in next five years? Have you clear vision on how you are going to develop it?
- Do you have forecasting and ordering optimization happening in real time? Is it real time optimization or what kind of cycle you use?
- Have your company outsourced artificial intelligence solutions?

Information process flow

- Do you exploit artificial intelligence across internal borders in supply chain network?

Additional information (opinion-based questions)

- Have you experienced that artificial intelligence have added value to your supply chain management and how? In which way?
- Where you can see your company at this point in this AI-based automation level figure? (Figure 5)
- Which of the following describes the best your knowledge of artificial intelligence? (Table 2)
- Is the concept gamification familiar?" and "Have you talked about it in your company?

3.4 Summary of Theoretical Framework

Many theories and frameworks were examined to find the best applicable framework for this research. This thesis must be up to date and that is the criticality for doing this research. Ellefsen et al. (2019) gave practical and comprehensive framework for this research to do it in logical and consistent way. With this framework, the research can find on which stage the company is in implementing AI technology in their SCM.

Framework from Vesset et al. (2018) aims to get deeper understanding of AI-based automation and that is why this framework is chosen for this research. Thus, combining these two frameworks, the results aim to be comprehensive and give valuable information to understand answers for research questions “what kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?” and “what is the adoption level of AI maturity?”.

Aim is to get valuable information from companies and answer for research questions. Different stages of AI implementation illustrate the current stage of implementations and perform maturity of their AI solutions. This information is valuable for the companies to concern a next step which they must take to be more efficient in implementing AI technology and improve their SCM field. The survey and interview questions based on research by Ellefsen et al. (2019) but interview questions make deeper understanding based on results of the questionnaire.

4 METHODOLOGY

The research is an exploratory study and it gathers preliminary information which help to make definition of the problems and suggest hypotheses (Sachdeva, 2009, pp. 14-15). Exploratory studies aim to construct understanding on how things are and on it is pragmatic approach. It fosters general knowledge of the phenomenon. (Helo, Tuomi, Kantola & Sivula, 2019) An exploratory study is useful if the research needs to clarify understanding of an issue, phenomenon, or problem. This methodology includes a search of literature, interviews of experts, in-depth individual interviews, or focus group interviews. Exploratory research is known for flexibility and adaptability to change. However, it commences with a broad focus, but it will narrow during the research process. (Saunders, M. et al., 2019. pp. 186-187)

Exploratory research usually relies on secondary research using available literature and data or in qualitative approaches using discussions with employees, management, consumers, or competitors. In more formal approaches using in-depth interviews with focus groups. Usually exploratory research is not useful for decision-making by itself, but it can help and provide insight to the situation. However, the results of qualitative research can give signs for “why”, “how”, and “when” something happens. Exploration is useful because the researcher does not have a clear vision what problems the research will meet during examining it. The area of the research may be new or vague, so that important variables might have not be known or thoroughly defined. (Sachdeva, 2009, pp. 14-15)

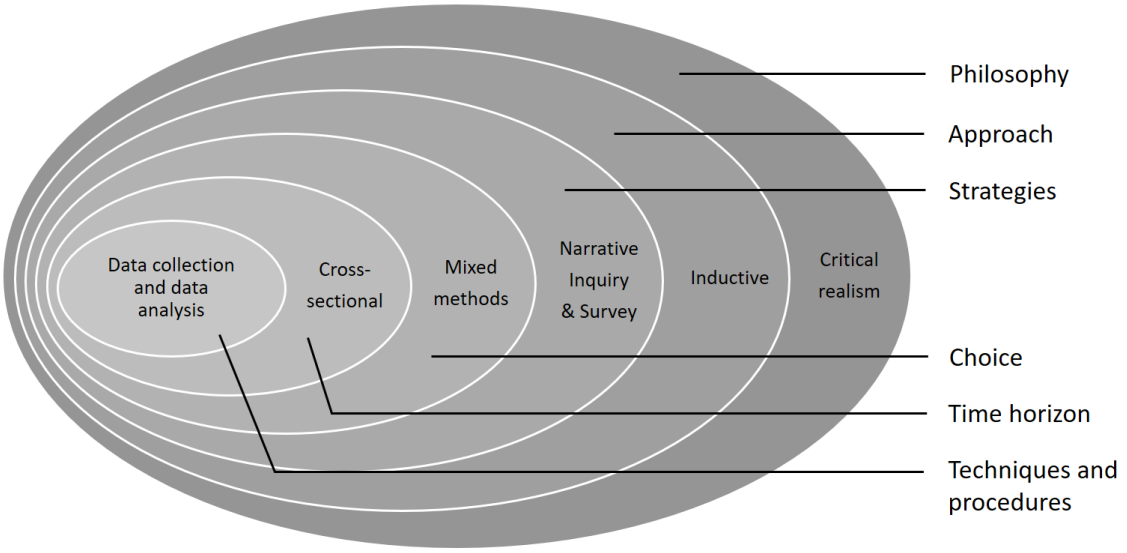

Figure 8. The research onion (adapted from Saunders et al., (2019). pp. 174).

Philosophy of this research is critical realism and approach is inductive. Critical realism makes shapes of the observations by the underlying structures of reality. In empirical ontology, critical realism is when events are observed and experienced. Purpose of inductive approach is to understand better the nature of the problem. Inductive approach allows to make predictions and alternative explanations of what is going on. (Saunders, M. et al. 2019. pp. 154-155) Strategies in this research are narrative inquiry and survey. Narrative inquiry follows qualitative approach and survey follows quantitative approach. These two approaches used together are forming mixed methods and those are explained in the next chapter. This research is cross-sectional study related to examining phenomenon at a particular time (Saunders, M. et al., 2019. pp. 212).

4.1 Quantitative and Qualitative Methodologies

This section maps out the quantitative and qualitative methodologies which are used in this research. Interview which will be held with supply chain professional is done by qualitative methodology. Online survey is quantitative methodology and it will be sent to supply chain professionals.

Quantitative methodology

Survey approach is concerned with human element and it is an examination of people's opinions by asking questions. This approach is valuable but human element may make them answer what they are assumed to answer, or respondent does not have enough experience or knowledge of the topic area. Structured surveys are often using Likert-scale from 1 to 5 options and semi-structured interviews are more open and let the respondents answer to the questions with words. (Helo, Tuomi, Kantola & Sivula, 2019.)

The survey strategy is usually related to a deductive approach and it is used in exploratory and descriptive research. Questionnaires are popular approach to survey strategy. It allows data collection with standardised data and comparison is easy. Particular relationships between variables and suggesting of possible causes can be defined with survey strategy. (Saunders, M., et al., 2019. pp. 193-194)

Qualitative methodology

The use of qualitative methodologies has been increased in different disciplines. It consists of many trends, data acquisition and analysis methods. There is not only one right way to do qualitative research. Like research usually, it has many lanes to go forward. (Saaranen-Kauppinen & Puusniekka, 2006a.)

A narrative inquiry is a qualitative approach used to describe generally the nature or outcome. This approach focuses on collecting experiences of participants and analyse these as complete stories. It seeks to keep chronological connections and sequencing of events to improve understanding of related area. In narrative inquiry, the participant is the narrator and it can be used in many ways and it may be used with small number of participants. Small and in-depth narrative interviews may prove to be valuable because of judgement of selection. This strategy is related to using small and purposive samples

because nature of intensity and time-consuming. (Saunders, M., et al., 2019. pp. 209-211)

Combining qualitative and quantitative methodologies (Mixed methods)

Differences between qualitative and quantitative research are related to what researcher wants to examine. Increasing validity is related to combining these two approaches which are established multiple methods and theories. (Hirsjärvi & Hurme, 2008) Quantitative and qualitative methods are combined in mixed methods research. It combines a variety of ways from simple structure to complex structure. (Saunders, M., et al., 2019. pp. 182)

According Hirsjärvi & Hurme (2006), there are four possibilities to combine qualitative and quantitative methodologies. First, qualitative results will be supplement to quantitative results. Second, quantitative result can be used to explain quantitative results. Third, qualitative approach can be used to create hypothesis to quantitative approach. Fourth, research uses first quantitative approach and based on that, quantitative approach creates typologies to qualitative approach.

Quantitative first, then qualitative. This method can consist different subareas and, in that way, those can supplement each other's. Otherwise, based on quantitative area the research can find interesting findings which can be examine more closely with qualitative methods. (Hirsjärvi & Hurme, 2008) This research uses first quantitative method because general knowledge of situation of AI solutions in SCM in Finnish large-scale companies was difficult to find in literature. The predictions of what the researcher must find does not even exist. After quantitative section, the research considers typologies for qualitative part.

Mixed methods use qualitative and quantitative approaches where they can be equally or unequally. The priority and weight of these may vary if one methodology has a dominant role. Mixed methods help to understand generalizability of the study and produce credibility with more complete knowledge. (Saunders, M., et al., 2019. pp. 183-185)

4.2 Research Process and Research Design

This chapter concentrates to outline the research process and its design. The research uses two approaches, qualitative and quantitative. Both approaches have own processes and designs.

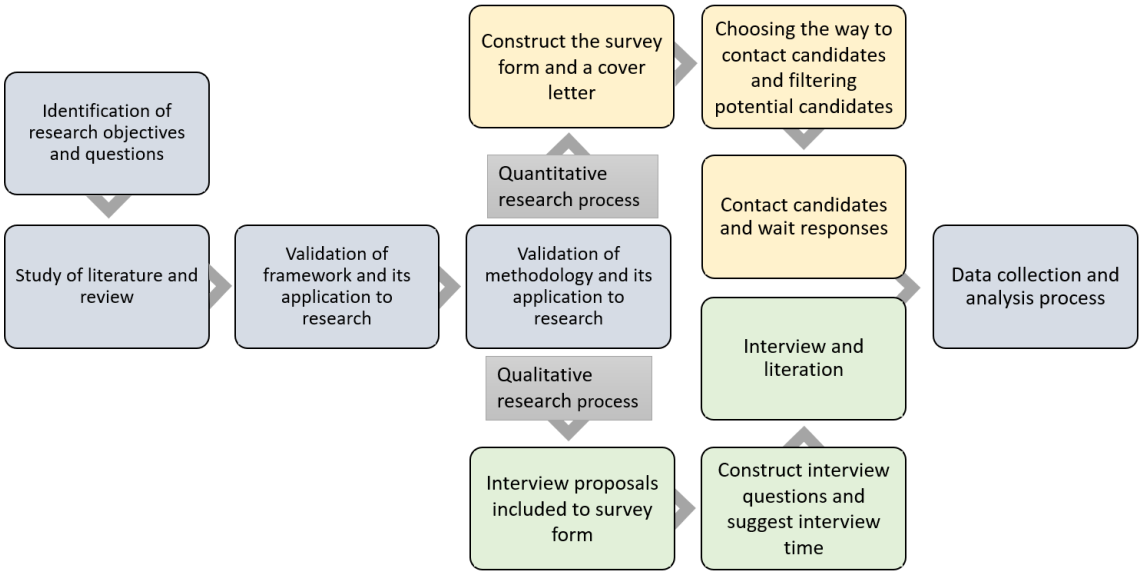

Figure 9. Research process.

Process of this research has been described in figure 6. Identification of research objectives and questions is the first step of research process. In this section the researcher considers what the research wants to achieve and what is the aim of the research. As mentioned, the questions are “What kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?” and “What is the adoption level of AI maturity?”. Objectives can be described to identify and analyse possible AI applications in supply chain, examine current status of AI implementations in SCM in

Finnish large-scale companies which have implemented some AI technology, do the research of AI application maturities in supply chain field and to help understand global influence for today's Finnish business actions.

Combining qualitative and quantitative research processes, the research use methodology which utilizes extract of quantitative approach to form a qualitative approach with typology. Examination of literature and reviewing it includes studying and reading articles, news, reliable research, and books related to subject area. During this section, information gathered while spending few weeks to get comprehensive understanding of the available information of AI and SCM knowledge.

After accomplishing the literature review, validation of framework related to research questions, objectives and purpose of the research have been examined. The framework for the research had to serve qualifications of the research. Many frameworks were studied, and the most suitable framework has been chosen. Validation of the methodology happened exactly in the same way as validation of framework. Both methodology approaches contain these steps.

Quantitative research process consists construct of survey form and a cover letter. Survey form structure is based on the framework and cover letter is attached to appendix. The way to filter and contact SCM professionals is described in chapter (4.3.1) quantitative data collection and how many of candidates responded.

In qualitative research process, the proposal of interviewing SCM professional included to the survey. Respondents answer to the questions and in the end, they will be asked would they like to have interview concerning the research topic. After collection of survey data, people who wants to participate in interview will be interviewed. After all these steps gone through, data collection and analysis are last parts of research process. Those are explained in chapters (4.3) Data Collection and (4.4) Data Analysis.

4.3 Data Collection

This research follows sequential explanatory data collection where quantitative approach is followed by qualitative approach. In research process, mixed methods research can be recognized as interactive and iterative. In these phases, one subsequently informs the next phase of data collection and analysis. (Saunders, M., et al., 2019. pp. 183-184)

4.3.1 Quantitative Data Collection

The research sampling contains of the population of SC workers in Finnish large-scale enterprises and the target population is SC professionals which means managers, directors, and development professionals. This is because they usually have the most comprehensive knowledge of what is happening in every decision and planning levels. Sample is taken from target population. According Saunders M., et al. (2019, p. 297), probability sampling is divided to four stages. First one must identify the frame based on the research questions and objectives. Second, the sample size must be decided. Third, decision of the sampling technique and selecting the sample. Fourth, checking that the sample is representative.

Quantitative data collection uses cluster sampling. Cluster sampling can be used when there is no available list of observational units. The idea is to first make a sampling of entities larger than the observation units, followed by selecting the observation units coming from these entities in the actual sample. (KvantiMOTV, 2003)

Preparation of quantitative data collection is to find out where potential respondents can be found. Thus, many of us have joined to online community service LinkedIn and contacting specific people is easy. Search functions enable to find people with keywords which are related to their profile. Searching potential members from LinkedIn happened with 30-days trial of recruiter profile because there are thirty free in-mail messages. Recruiter profiles give an opportunity to search specific people with filters and keywords.

Filters and keywords are Finland, Supply Chain Manager, Supply Chain Director and Supply Chain Developer. It is not possible to filter size-scale of the companies. Filtering people who work in large-scale company size happen one-by-one method. First step of filtering is to determine what is the company and adding the company name to Finder.fi and check how many people work in that company. The company is determined as a large-scale when there work more than 250 people. Thirty messages via LinkedIn recruiter profile have been sent and cover letters have been sent via e-mail. Potential SCM professionals have been filtered for e-mailing list in the same way as LinkedIn in-mail list. Difference between e-mail list and in-mail list is that researcher must examine how e-mail structure constructed e.g. “firstname.surname@student.uwasa.fi” and it must be examined before sending e-mail.

Online questionnaire participation proposal has been sent successfully to seventy SCM managers, directors, and developers who are working in Finnish large-scale companies. Cover letter with a link to questionnaire has been sent via LinkedIn and e-mail. Questionnaire participation proposal has been sent in three different days and one reminder messages one week after. First round was sent in 12th of May 2020 via e-mail in total thirty messages and second round 13th and 14th of May 2020 via LinkedIn recruiter profile. After all, thirty LinkedIn in-mail messages were sent, the reminder messages could not be sent because limitations of free messages avoiding spamming. Reminder messages were sent in 19th of May 2020 via e-mail to thirty professionals.

After all, ten responses were collected. The response rate can be calculated by total number of responses divided by total number of samples minus ineligible. Thus, 10 responses which is divided by 70 and there are no ineligible responses, response rate is ~0,1429 in other words 14,29 %.

4.3.2 Qualitative Data Collection

The qualitative part is semi-structured and implemented with in-depth interview. Semi-structured interviews are non-standardised, and they are referred as a qualitative research interviews. Philosophical assumptions are predetermined in list of themes and it allows to underpin reality of what the research seeks to reveal. When undertaking explanatory study, the research will likely follow semi-structured and in-depth interview. It allows to interviewees explain or build on their answers. Also, it gives an opportunity to add meanings for the data which is obtained. The discussion might lead to the areas which the researcher has not previously considered. The research should collect rich and detailed set of data. If the questions are open-ended or complex, semi-structured interview is the best solution. (Saunders, M., et al., 2019, pp. 437; 444-445)

As (4.2) research process shows, the interview proposals were included in survey proposal but also directed interview proposals were sent to SCM professionals. Answers for interview proposals were that they do not use AI in their SCM operations. Thus, altogether 70 proposals were sent. All ten questionnaire respondents answered “No”, when they asked if they want to be interviewed. However, one of proposal receiver contacted and was eager to participate in interview.

Interview was held using Microsoft Teams software and duration of interview was 00:17:48. Interview has been held in Finnish on 2nd of July 2020. The interview included questions based on survey results and it focused to find out deeper explanations to survey results.

4.4 Data Analysis

Although the interview and survey were held in Finnish, the literation was translated to English. Literation helps to combine typologies from interviewees’ speech. Analysing the data happened using typology which means the compilation of typical things and condensing the material into illustrative types. From interview materials, there can be

searched particular types of responses or parts of interviews. These are linked by elements and therefore can be representing a type. The descriptions combine the common and typical elements in the different responses. (Saaranen-Kauppinen & Puusniekka, 2006b)

Typology requires active working of the material and goal-oriented action towards thorough compactification. In typology, every result is classified to two or more types based on key points. Deviations concerned by new perspective can be to decode general perception of the phenomenon. (Hirsjärvi & Hurme, 2008)

Quantitative data analysis is nominal which means it is descriptive data analysis. The descriptive data cannot be defined numerically. Rather, data can be divided to categories. The categorical data measurement can be classified into sets according characteristics. Characteristics identify the variable. (Saunders, M., et al. 2019. pp. 567-569) This research can categorise the data to physical process flow data, information process flow data and additional data. Also, the research determines the data to AI maturity model and AI-based automation framework. The quantitative data presents statistics straight from Google Forms where the questionnaire appears. The Google Form analyses the data in Likert-scale charts and pie charts. The analysing presents results of typologies and categorised commonalities.

5 RESEARCH RESULTS

This chapter presents research results as qualitative and quantitative parts. The research results are analysed to concepts in the end. Background of respondents are defined in beginning of the results sections which contain occupational title, industry description and years of experiences. Calculations of experiences are calculated in average and median.

Quantitative results are shown as pie chart and Likert-scale. The percentage values are presented in the charts and scales and in the words. Altogether, sixteenth questions were asked and in the end three questions by free word. After quantitative part comes qualitative part. Twelfth questions were asked from the respondent and extracts of interview are presented where interviewer asked questions and respondent answered. The interview is presented as it held. Also, follow-up questions have been asked from the respondent which were not part of question pattern.

The questions form construct from aspects as physical process flow, information process flow and additional information. In the conclusion part, these aspects are considered, and clear statement presented.

5.1 Quantitative Results

Background of respondents

Respondent	Industry description	Years of experience of SCM	Years of experience of AI
Supply Chain Manager	Energy industry	10 years	None
Shift Manager	Logistic industry	20 years	0-1 year
Senior development manager	Pharmaceutical industry	29 years	None
System manager	Food industry	Supply chain system support	None
Development manager	Wholesale industry	10 years	None
Head of Supply Chain	Identifiable	15 years	0-1 year
Data analysist	Retail industry	23 years	20 years
Director, DSCM	Technology industry	20 years	0-1 year
Supply Chain Planning Director	Paint industry	1 month*	1 year
Program Manager	Identifiable	15 years	0-1 year

Table 3. Background of respondents.

**Might have misunderstood the question and thought that how long he/she has worked in current job. This is not counted to median and average calculations.*

Calculation	Years of experience of SCM	Years of experience of AI
Median	17,5 years	1 year
Average	17,75 years	2,5 years

Table 4. Calculations of experience years.

Questions and answers

(1) First question aimed to specify companies which use AI technology in their SCM field. Companies which do not use AI solutions were able to go question number seven. As seen in figure (10), total responses were ten and only 30% (3 answers) of respondents answered “No” and 70% answered “Yes” (7 answers).

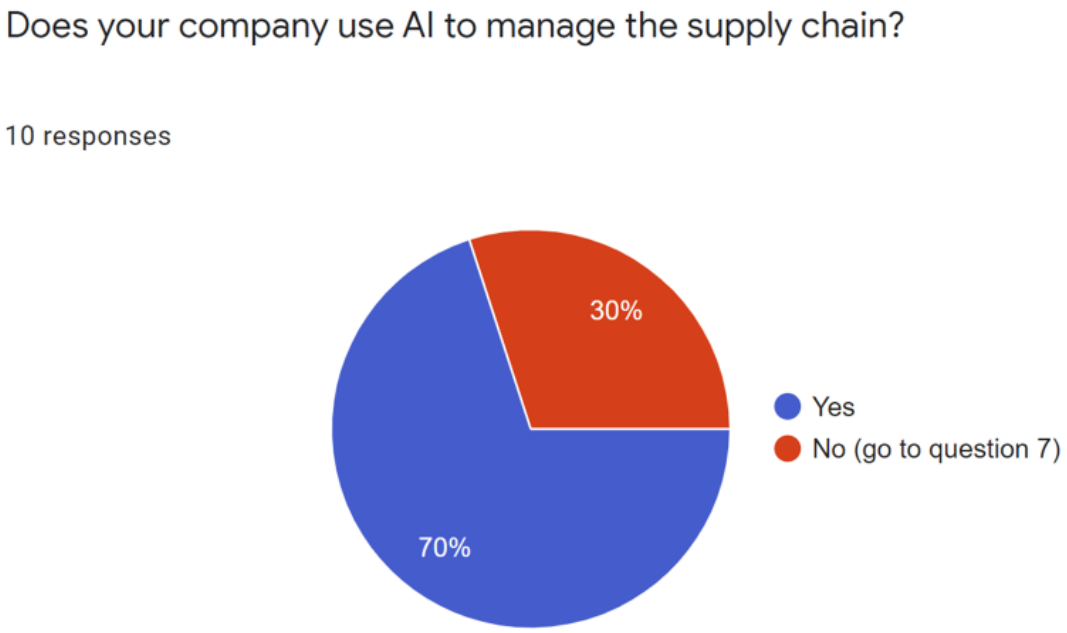

Figure 10. Use of AI in SCM.

(2) Second question concentrated to companies which use AI solutions and the question aimed to get to know how important AI is in the SCM. All seven respondents answered to this question related to previous question. The question structure was from 1 (no important at all) to 5 (very important). As seen in figure (11), four respondents answered 3 (neutral) and three respondents answered 4 (important). Neutral answered 57,1% and important answered 42,9%.

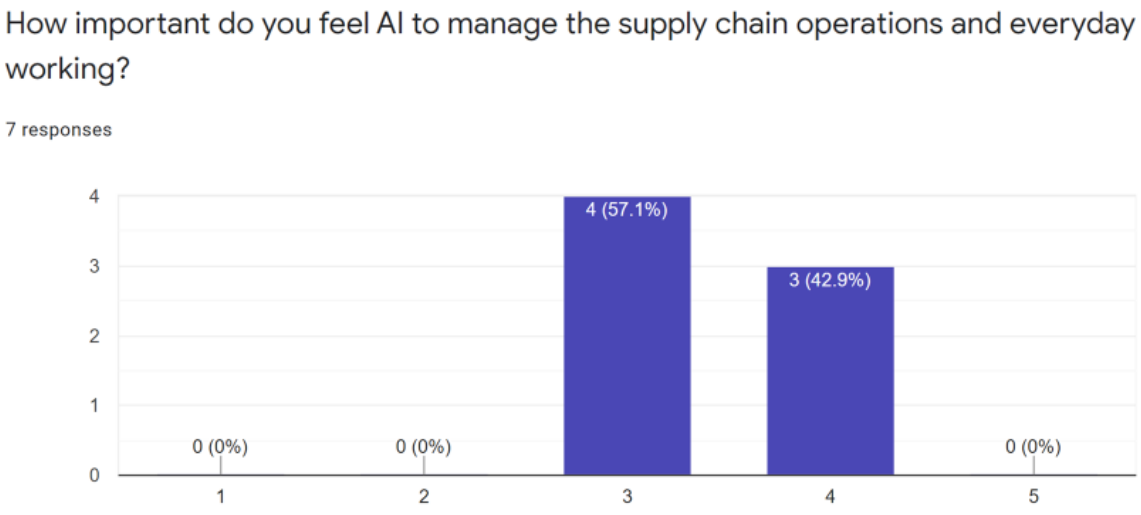

Figure 11. Managing SC operations with AI.

(3) Third question aimed to find out, do the companies exploit AI across internal borders. In figure (12) can be seen that majority of respondents answered “Yes” 42,9% (3 answers). “No” (2 answers) and “I do not know” (2 answers) split even to 28,6%. All seven respondents answered to the question.

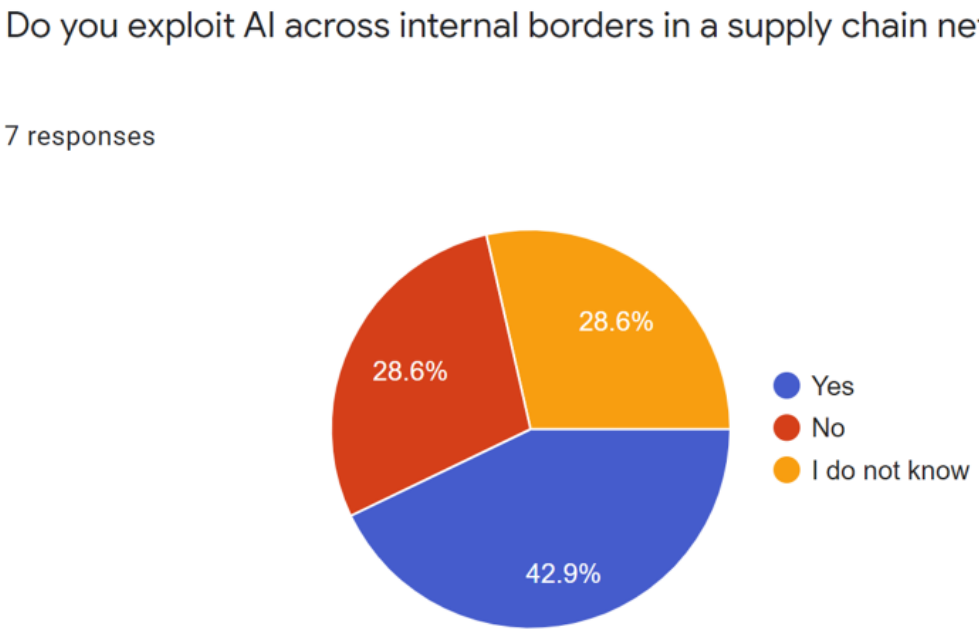

Figure 12. Exploiting AI across internal borders.

(4) Fourth question map out behaviour of AI, the decision-making. Majority of responses were “Yes” by 57,1% (4 answers). “No” answers were 42,9% (3 answers) and they who answered no, must go to question number 7. All seven respondents answered to the question.

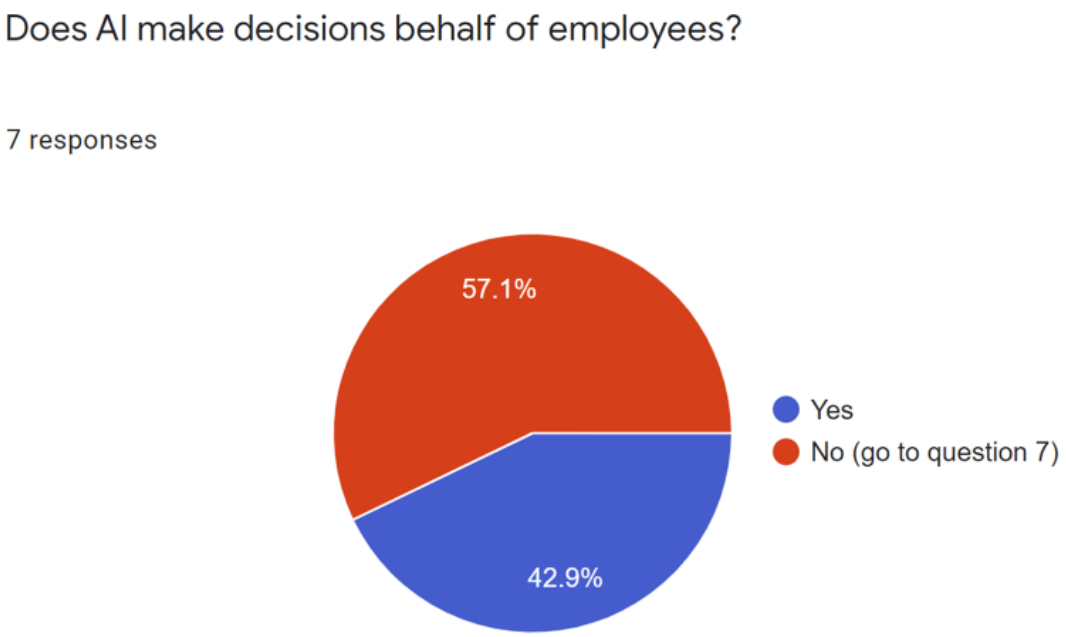

Figure 13. AI decision-making on behalf of employees.

(5) Fifth question concentrated to type of decision-making. As in chapter “Supply Chain Decision Levels” all the decision levels in SCM are considered. Majority of respondents answered “Operational decisions” 75% and “Tactical decisions” answered 25%. No answers to sections “Strategic decisions” or “I do not know”. Four respondents answered as they should related to question number four.

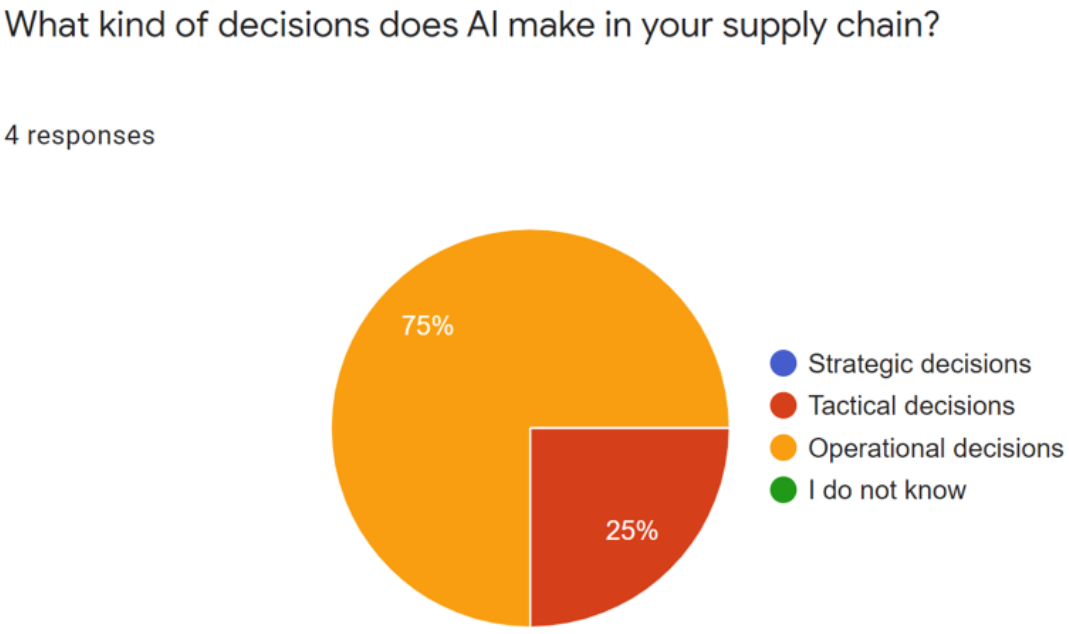

Figure 14. Type of AI decisions.

(6) Sixth question remains in decision-making questions. Companies were asked about monitoring of decisions made by AI. Majority of respondents answered “Every day” by 50% (2 answers). “Once a month” and “Less frequently” (than any other option) made it even by 25% (1 and 1 answers). All four respondents answered to the question.

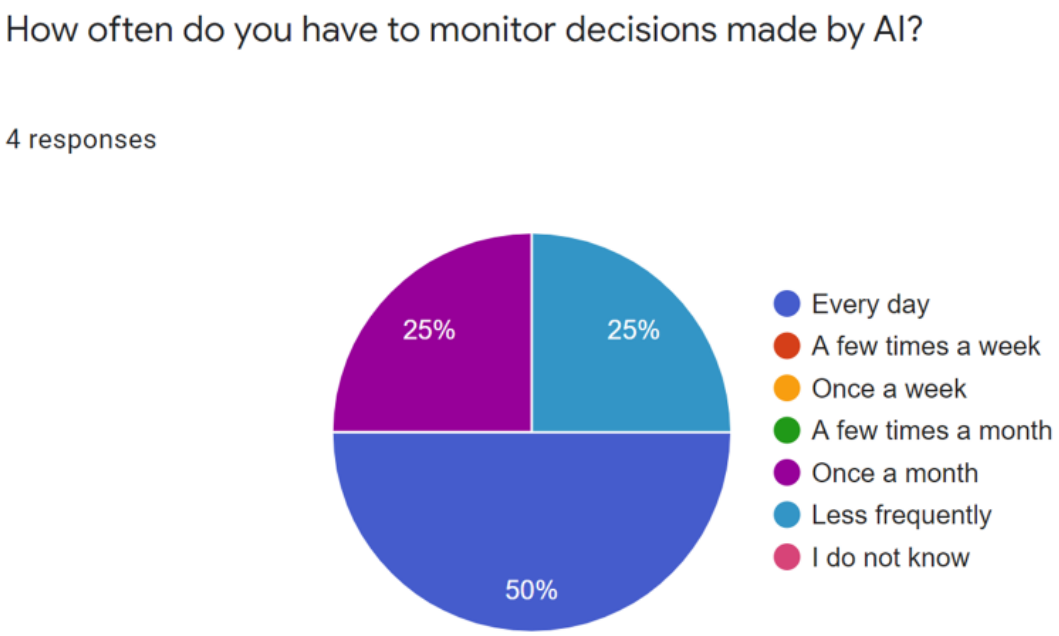

Figure 15. Monitoring AI.

(7) Question number seven, where every respondent had to answer, aims to understand companies' willingness to develop AI solutions in the next five years. Any of respondents did not answered "I do not know", "No" or "Improbably". Answers divided almost even by "Yes" 40% (4 answers), "Highly like" 30% (3 answers) and "Quite likely" 30% (3 answers). All ten respondents answered to the question.

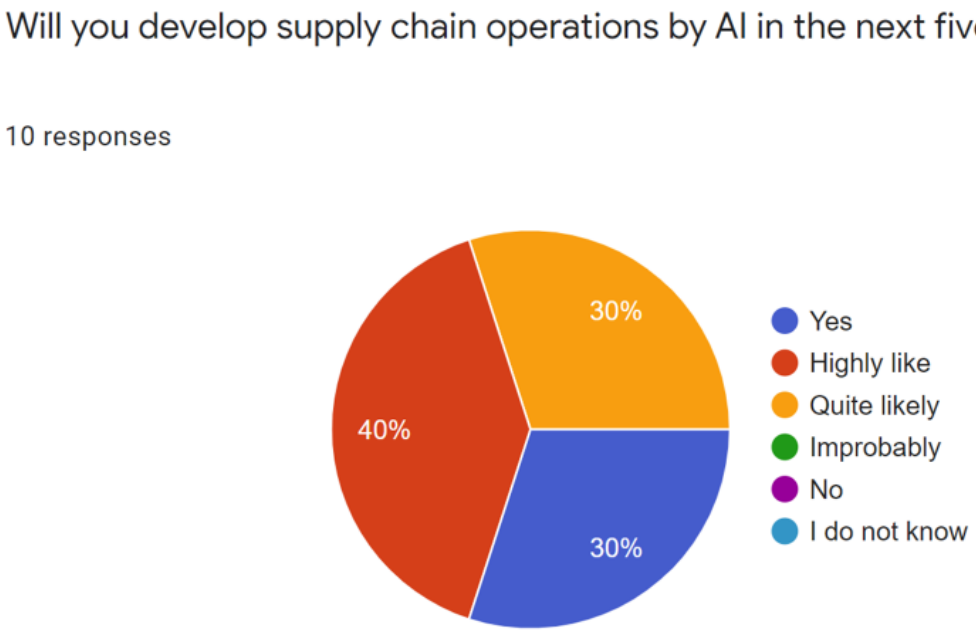

Figure 16. Will of developing AI in near future.

(8) Eighth question concentrated to a resource of AI, big data. Majority of the respondents answered “System collect data, but not big data” 60% (6 answers). “Yes” answers were 20% (2 answers), “No” and “I do not know” answers were 10% (1 and 1 answers). All ten respondents answered to the question.

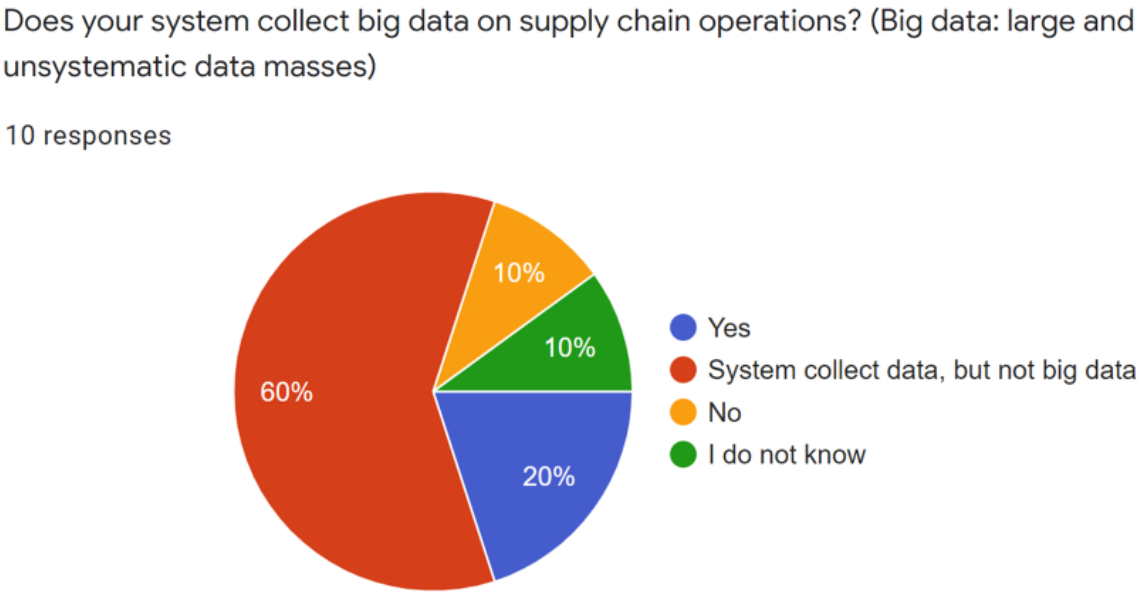

Figure 17. Big data collection.

(9) Ninth question was opinion-based question and tried to find out how professionals think AI adds value to SCM. The question structure was from 1 (Not at all) to 5 (A lot). Majority of respondents (70%) answered stage four which means “Quite a lot”. Stage 3 which means “Neutral”, got two responses (20%) and “A lot” got one response. All ten respondents answered to the question.

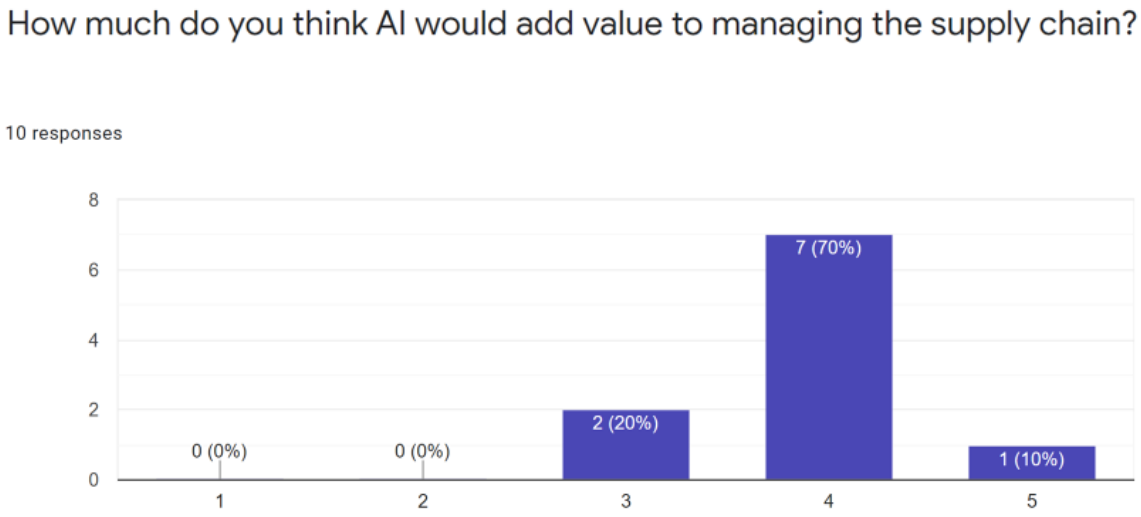

Figure 18. AI value-creation for SCM.

(10) Question number ten was opinion-based question and aimed to find out influence of AI to flow of information in SC network. The question structure was from 1 (Not at all) to 5 (A lot). Majority answered stage four which means “Quite a lot”. It contains 70% of respondents. Two out of ten respondents (20%) answered stage three “Neutral” and one out of ten respondents (10%) answered stage one which mean “Not at all”.

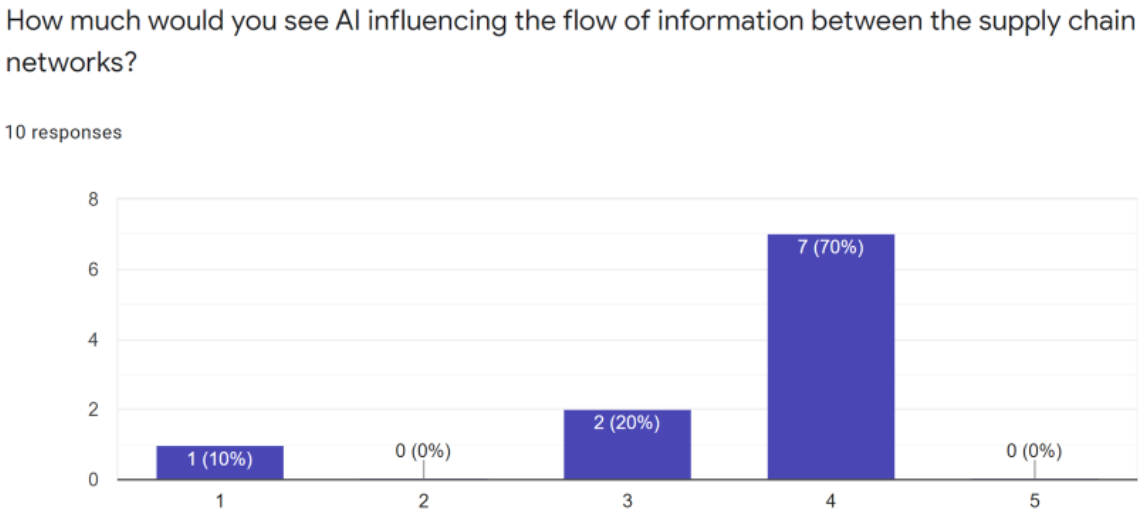

Figure 19. Flow of information in SCN.

(11) Eleventh question was opinion-based question and it aims to find out do the supply chain professionals think that artificial intelligence solutions bring transparency for supply chain processes. The question structure was from 1 (Not at all) to 5 (A lot). Four respondents answered number 4 which means “Quite a lot”. It contains 40% of respondents. Three respondents answered “Neutral” (30%) and three respondents answered, “Not at all” (30%).

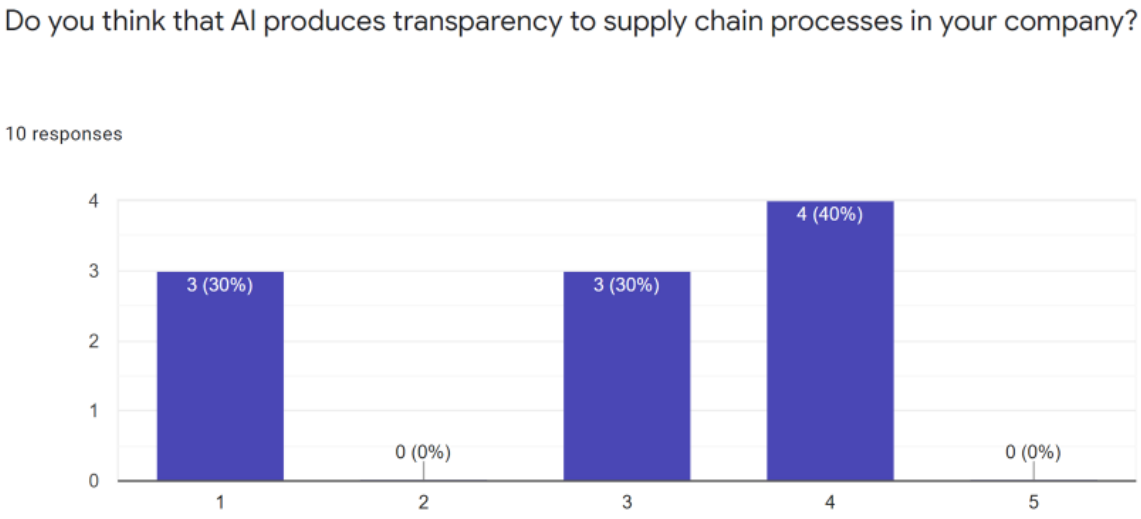

Figure 20. Producing transparency with AI.

(12) Twelfth question concentrates to find out how often companies use spreadsheets in their supply chain operation to forward information. Scale was from “Every day” to “Less frequently” (than once a month). Majority of respondents answered, “Every day” (50%) and just a one respondent less answered “A few times a week” (40%). One respondent answered, “Once a month” (10%).

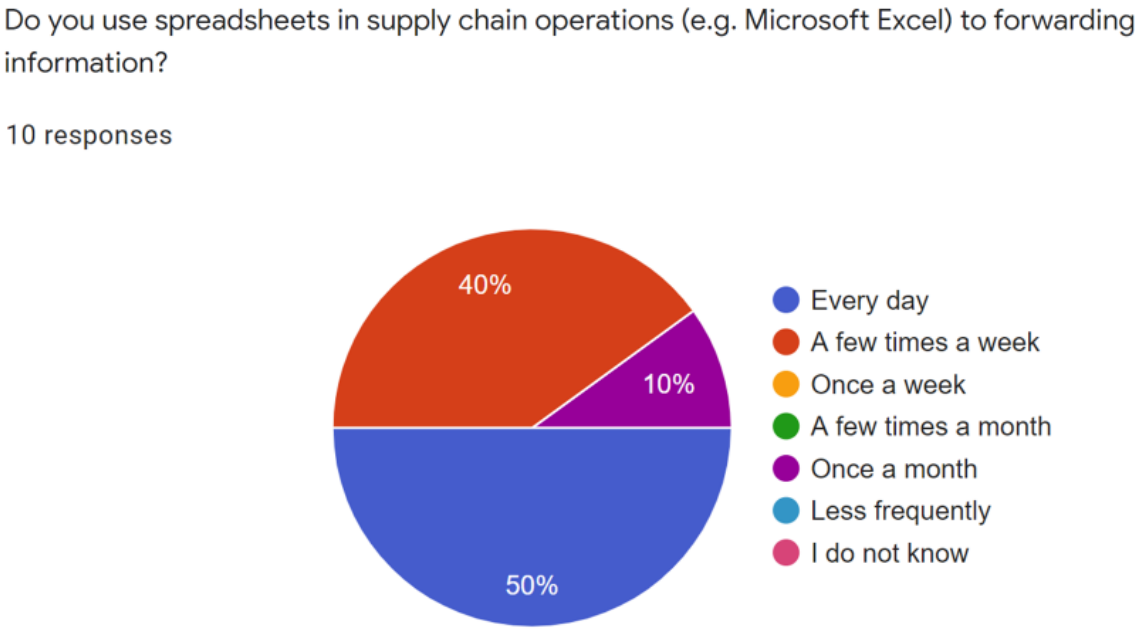

Figure 21. Use of spreadsheets for forwarding information.

(13) Thirteenth question was opinion-based question. It concentrates to map out maturity level of AI in respondents' companies. Majority answered "Prepared, basic understanding of AI" (50%). "Skilled, own knowledge of AI as well as knowing how to proceed, but nevertheless there are limitations and problems" (20%) and "Novice, no know-how about AI" (20%) got both two answers. "Advanced, experience and skill in AI demonstrated in managing different processes" (10%) got one answer.

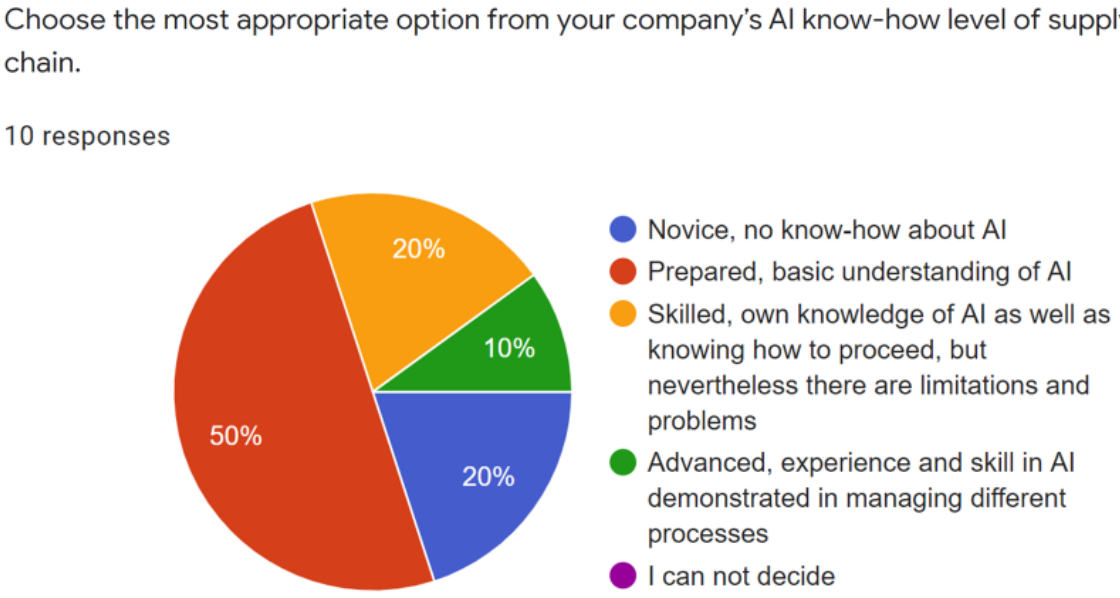

Figure 22. AI know-how level.

(14) Fourteenth question was “What kinds of tasks AI performing?”. It concentrates to map out what tasks AI perform in SCM. Two respondents did not answer because they do not use AI in their SCM.

Respondent	Industry description	Answer
Supply Chain Manager	Energy industry	Including transportation and inventory optimization.
Shift Manager	Logistic industry	Creating forecasts
Senior development manager	Pharmaceutical industry	*(no answer)*
System manager	Food industry	Calculating forecasts.
Development manager	Wholesale industry	Supplement and order optimization, product information optimization.
Head of Supply Chain	Identifiable	*(no answer)*
Data analysist	Retail industry	Routine tasks.
Director, DSCM	Technology industry	Planning.
Supply Chain Planning Director	Paint industry	Clustering of forecasts, i.e., matching forecast models according to other similarities automatically.
Program Manager	Identifiable	Forecasting based on history.

Table 5. Performed tasks of AI.

(15) Fifteenth question was “At what different stages of the supply chain does the work produced by AI show up?”. This question finds out stages where companies use AI in their SCM. Two respondents did not answer to this question.

Respondent	Industry description	Answer
Supply Chain Manager	Energy industry	In implementing deliveries.
Shift Manager	Logistic industry	In preparation, like planning shifts.
Senior development manager	Pharmaceutical industry	*(no answer)*
System manager	Food industry	Demand planning.
Development manager	Wholesale industry	In the Order-Supply Chain.
Head of Supply Chain	Identifiable	*(no answer)*
Data analysist	Retail industry	Refine demand and supply upstream.
Director, DSCM	Technology industry	A Demand-Side Platform (DSP).
Supply Chain Planning Director	Paint industry	Forecasting.
Program Manager	Identifiable	Sales and Operations Planning (S&OP) and it reflects to the production plan as well as the purchasing.

Table 6. Stages where AI show up.

(16) Sixteenth question was “What kind of AI do you use to control the supply chain? (e.g. robotics, machine learning, etc.)”. Question concentrates to find out what AI solutions in SCM. Four respondents did not answer to the question.

Respondent	Industry description	Answer
Supply Chain Manager	Energy industry	*(no answer)*
Shift Manager	Logistic industry	In the preparation of forecasts. Robotics are used internally to prepare deliveries.
Senior development manager	Pharmaceutical industry	Robotic Process Automation (RPA) is in a period of expansion, however, I would not encompass it as an AI.
System manager	Food industry	*(no answer)*
Development manager	Wholesale industry	Machine learning.
Head of Supply Chain	Identifiable	*(no answer)*
Data analysist	Retail industry	Deep- and machine learning.
Director, DSCM	Technology industry	Robotics.
Supply Chain Planning Director	Paint industry	External software.
Program Manager	Identifiable	*(no answer)*

Table 7. Type of AI to control SC.

5.2 Qualitative Results

Background of respondent

Respondent	Industry description	Years of experience of SCM	Years of experience of AI
Project Specialist, Supply Chain Development	Retail industry	1,5 year	0,5 year

Table 8. Background of interview respondent.

Questions and answers

(1) First question was “What kind of artificial intelligence you exploit in supply chain management?”. Respondent answered:

“We have actions related to warehouse like inventory management and inventory management system. And then systems for material management. I cannot say what systems we have but in category level, inventory management and material management have systems which are related to purchase orders. It forecasts what kinds of supplies it should order and how. It is order management. It might be the right word. Order management and the other one are systems for inventory.”

(2) Second question was “How it accomplishes forecasts and order management? Does the work of artificial intelligence occur anywhere else?”. Respondent answered:

“It is in order management and forecasts. It can be monitored and in warehouses it does forecasting and like maintains the warehouse, workers are not involved that much.”

(3) Third question was “Have you experienced that artificial intelligence has added value to your supply chain management and how? In which way?”. Respondent answered:

”Of course, and more you use it, the more it gives. Or maybe not until specific point, but what we have used it has brought added value. It has added value because it eliminates manual work tasks. Work that people do decreases when artificial intelligence comes along with and helps you. Especially in order management employee must monitor more and artificial intelligence brings support to what you are doing but in warehouse it maintains the inventory management. It does include the monitoring but in bigger part the artificial intelligence does it.”

(4) Fourth question was “Do you exploit artificial intelligence across internal borders in supply chain network?“. Respondent answered:

“I think that pretty little. I cannot say exactly but what I have been experienced in one and half year, we do not. Of course, we can share something with partners but not really collective help.”

(5) Fifth question was “Does artificial intelligence make decisions on behalf of employees and are those strategical-, tactical- or operational decisions and results?“. Respondent answered:

“Yes, those are operational decisions mostly and actually altogether operational decisions in order management and in warehouse. And in material flow it does kind of order proposals. It does not take decisions at the end but makes order proposals and then employee makes the decision. In warehouse it controls operational actions. The artificial intelligence controls it what employee does.”

(6) Sixth question was “How often you must monitor the artificial intelligence? Daily, weekly, or how many times?”. Respondent answered:

“It is daily in both departments. Especially in material management it is daily. There the decisions cannot be made without employee being involved in the decisions making. Like those order proposals. And then in warehouse, employee is monitoring all the time what happens in the warehouse but does not need to intervene so much. But under constant supervision.”

(7) Seventh question was “Where you can see your company at this point in this AI-based automation level figure?“. (Figure 5. Levels of AI-based Automation). Respondent answered:

“Yes, altogether I see that B. Human led and machine supported. These two different departments which we have talked about, material management and inventory management. In warehouse it is more like machine led and human supported or human governed. But altogether I would say human led and machine supported. We still have to make improvements.”

(8) Eighth question was “Which of the following describes the best your knowledge of artificial intelligence? (Table 2. AI maturity model). Respondent answered:

“We are in the B section. AI ready, basic knowledge of artificial intelligence but we cannot say that we are proficient. In development department we know those possibilities but not altogether like the company is not at that point.”

(9) Ninth question was “Do you have the will to develop it and do you see the potential? And will you develop it in next five years? Have you clear vision how you going to develop it?”. Respondent answered:

“Yes absolutely, I have to say that if we get support to artificial intelligence solutions and we recognise that it is reasonable. Then we would like to map out and in case of possibilities implement anything which supports the company, people actions and working. We recognize the potential but there are big departments like material management and warehouse. Altogether both parties in this supply chain. We are going to map out, how we can exploit the artificial intelligence and bring it forward. If we see, what is reasonable, we are going to develop it in five years but still do not have a plan for that. Or maybe it might be at the executive level but in this development team we do not have the vision for five years. Like exact plans. We know that we want to develop, and artificial intelligence is todays’ thing and with it we can decrease manual work away from peoples’ task list. With it we can develop the overall process and benefit of cost savings, for example.”

(10) Tenth question was “Does your forecasting and ordering optimization happen in real time? Is it real time optimization or what kind of cycle you use?”. Respondent answered:

“It might not be real time. And it is not. Every day comes new calculations and optimizations, but it does not happen every second. In warehouse section it sure happens many times a day but in material management it probably happens less frequently. It might be once a day refreshing the information. Both have a bit differences in timelines.

(11) Eleventh question was “Is the concept gamification familiar?” and “Have you talked about it in your company?”. Respondent answered:

“Yes, a little bit.” and ”No, not in our company. It has not have been on paper and we have not talked about this at all. We are too far away in our company.”

(12) Twelfth question was “Has your company outsourced artificial intelligence solutions?”. Respondent answered:

“Yes, of course we get support from external companies. That we have outsourced, I would like to say, partly but not all.”

5.3 Summary of Research Results

As a result of findings, Finnish large-scale enterprises do use artificial intelligence in their SCM, and they experienced AI as a neutral and important function in their operations. Interviewed person mentioned *“more you use it, more it gives. Or maybe not at until specific point, but what we have used it to bring added value”.* Many of companies use AI across internal borders but likely many of them did not use or did not know do if they use. AI does not do decisions on behalf of employees, but likely AI makes order proposals in material flow section and in warehouse it supervises what employee does. As many of respondents answered: when they use AI for forecasting, demand, and planning, it helps employees to do decisions.

Companies’ AI decision-making happens in operational field, but minority also operates in tactical field and monitoring those decisions is daily. In warehouse intervening to AI decisions is less than in other operations. Companies’ are intended to develop SCM operations by AI in next five years and they would like to do research of it before implementing anything. When it is concerning of big departments like inventory management and material management, it must be examined how companies can exploit AI.

Optimisation of operations does not happen in real time. There are gaps between demand and forecasting. Results shows that companies collect data, but not big data which is important for AI. Opinion-based questions shows that SCM professionals think that AI adds value to managing the SC and AI increases flow of information between SC networks. Transparency in SC processes got divided opinions, but majority thought that it

produces transparency in SC processes. Many companies still use spreadsheets for forwarding information at least few times a week.

Opinion-based question concerning the framework model, companies perceive themselves as prepared and skilled for AI technology. Minority perceive themselves as novices and advanced. AI performs tasks like optimisation, forecasting, routine tasks, planning and clustering. AI shows up in stages like preparations, implementing, planning, supply upstream, demanding and S&OP. Companies use AI solutions for managing supply chain operations like RPA, machine learning, deep learning, and external software.

5.4 Validity and Reliability

Validity

The chosen methodology was considered precisely, and strategy is valid. After the questionnaire, the research faced the problem that the professionals were not willing to participate to the research. This might be due to lack of AI solutions. Assuming, they did not want to participate because they do not use AI in their SCM, even though the proposal letter consist phrase "*You can take a part of survey even if you do not have implemented AI solutions*".

Internal validity involves tactics which test the validity of inferences. The results of the research do not give exact observations of which AI solutions are used in SCM. However, the research focuses on getting general understanding of AI solutions that is used in SCM and even though data sample was small, the results accomplish to answer for the research question. Adoption level of AI maturity is reached and in general, the research shows the AI maturity level in SCM of large Finnish enterprises.

Questionnaire and in-depth interview were thought carefully and followed by the used frameworks. Sixteen questions were asked in questionnaire and 12 questions in interview. The original framework research asked 49 questions, but in this research, all the

aspects were considered. Also, the response rate could have decreased due to the issuing of a time-consuming if all 49 questions would have been asked.

Reliability

The survey and interview have been sent to SCM professionals who might not understand AI solutions. IT-experts might have better understanding of company's status of implementations related to AI and this led to decreasing reliability. For better results, the survey and interviews should be held with IT-expert and SCM professional, thus, both aspects could have been considered and noticed. In this research, respondents AI experience is extremely low. Median of AI experience is one year, and average is 2,5 years. Due to this some respondents might not understand the possibility that AI does tasks in background processes.

Due to lack of respondents and interviewed this research shows only a small observation of the topic area. 70 proposals were sent, only 11 responses were collected. This led to unexpected problem when potential respondents were hard to find because a list of SC professionals does not exist. Also, lack of responses was problem of this research. The research would have been more extensive if more responses were collected.

Even though this research is cross-sectional, the internal reliability could be measured again. It means that the research is repeatable. If the results have variation, it means that the companies have implemented more sophisticated AI solutions, or it is a random variation. The framework of this research has been made for examining AI maturity and it is usable for measuring AI maturity in different situations. This means that external reliability is low.

6 CONCLUSION

Objectives of this research were to identify and analyse possible AI application in SC, examine current status of AI implementations in SCM in Finnish large-scale enterprises which have implemented some AI technology, do the research of AI application maturities in supply chain field, and to help understand global influence for today's Finnish business actions. The research aims to answer questions "What kinds of AI applications Finnish large-scale companies have implemented in their supply chain management?" and "What is the adoption level of AI maturity?".

As findings show, identified AI applications in SC are machine learning, deep learning, robotics, and some companies use external software. The use of these applications is limited to forecasting and optimisation of different SC operations. Forecasting and optimisation are calculations which turn to algorithms and suggest the highest likelihood of success. These are most likely a basic form of AI. Because generally big data sets are not collected in companies, they are not able to use sophisticated AI technology. Most likely this is the reason for early adoption level of AI technology and the data has not been collected enough to act as it could. This AI can be classified as supervised learning. Some companies use AI across internal borders which strengthens partnership and decreases bullwhip effect.

There are obstacles to implement AI solutions as interviewed said. Even development department might not have vision of what is the next step toward AI technology, but executive level might have. As a finding, the AI readiness level of Finnish large-scale enterprises, must concern concepts digitalisation, robotics, autonomy, intelligence, automation, and self-awareness. These pillars lead to conclusion of AI maturity model stage. Physical – and information process flow observations are combined to AI readiness levels in table 9. Examining these observations, the study ends up with a conclusion of AI maturity level and it is determined below (figure 23).

AI readiness	Physical process flow	Information process flow
Digitalisation	In everyday working, companies slightly felt AI is important and helpful. Companies have will to develop solutions related to AI, but those plans are not on top.	Companies felt that AI adds value to managing the SC.
Robotics	Internally preparing deliveries. AI produces operational decisions but also tactical decisions.	The systems collect data but in general the data is not big data.
Autonomy	Companies often monitor decisions made by AI and decisions made by AI are not common.	Companies use spreadsheets often to forward information.
Intelligence	Companies use machine learning, deep learning, RPA, and external software. Those are used for preparations, implementing, planning, supply upstream, demanding and S&OP	Some companies exploit AI across internal borders, but majority do not know or do not exploit. However, the shared information might not be helpful for SCN.
Automation	AI used in inventory management, material management, forecasting, routine tasks, and order proposals.	The optimisation does not happen in real time.
Self-awareness	Companies recognise themselves prepared implementing AI. Companies try to exploit possibilities of AI in their SCM.	Companies felt that AI increases quality of communication between the SC networks.

Table 9. Physical – and information process flow observations in AI readiness levels.

Even though companies felt that they are at “AI Ready” stage, the results show that many of them do not have big data which is important for preparing AI solutions. Major issues are lack of strategical and organisational preparedness to implement AI. As seen in figure (23) of measurement of AI maturity and AI-based automation level, the vertical measurement sets to lower “AI Ready” stage because some companies have implemented AI solutions. The horizontal AI-based automation level sets to “human led, and machine supported” because companies often must monitor decisions made by AI. At this level, human makes analysing, produces insights using tools and makes decisions based on machine suggestions. Also, human implements the decisions and acts based on decisions. Anyone did not mention many possibilities which AI can produce e.g. weather-related solutions or prevention downtime of maintenance predicted by AI.

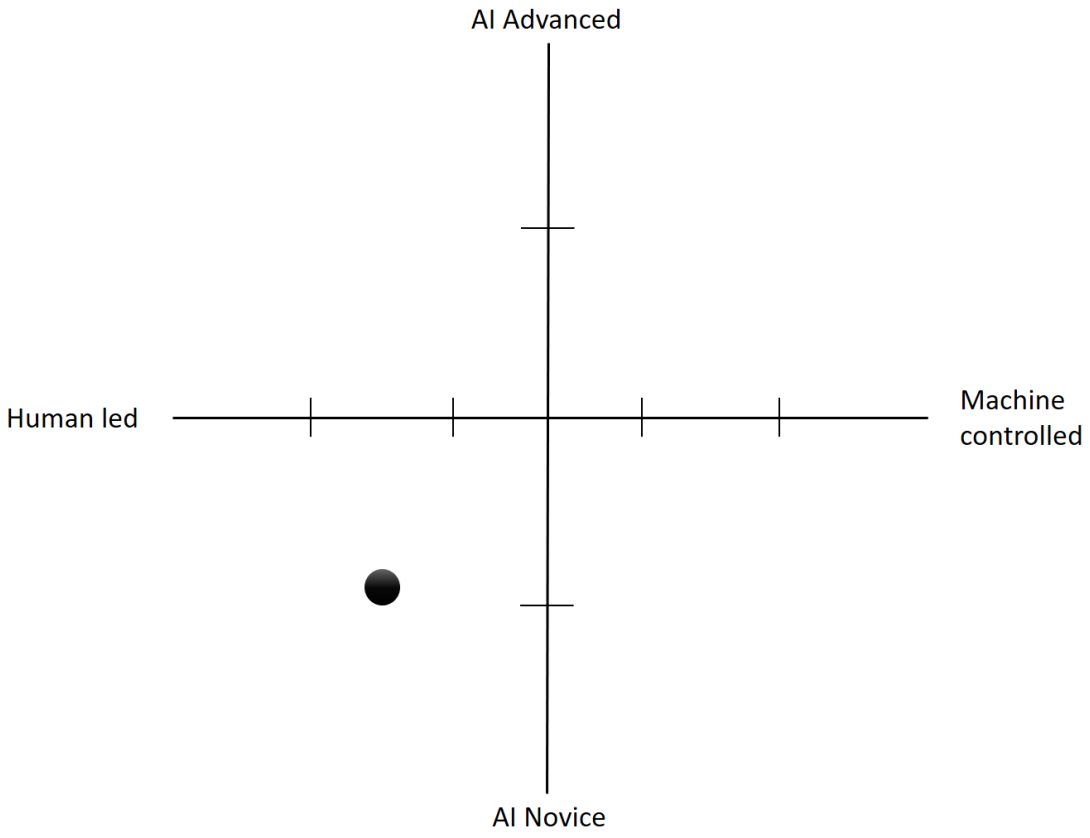

Figure 23. Measurement of AI maturity and AI-based automation level (adapted and combined from Ellefsen et al., 2019 and Vesset et al., 2018).

Comparing to other studies related to implementation of AI in Finnish enterprises, Prime Minister's Office (2019) made a research of Finnish competences in the area. They examined the subject and concluded that there are three dimensions which must combine. Those are business acumen, IT-knowledge, and comprehensive analytical knowledge. According to the research, they stated that requirements of these expertise's have led to situation where companies do only experiment and deployment remains unrealised. Technology Industries of Finland ended up in similar results. They stated that ability of launch and scale projects and experiments based on AI is important for companies and public sectors. Also, funding and investment are needed to especially scale up experiments. Microsoft stated in their research that many Finnish companies have undertaken successful pilot projects but too many companies are still in waiting position on AI. Their research found that from 277 companies, only 4% of participants in the study exploits AI in comprehensive and in sophisticated way. (Prime Minister's Office, 2019) These studies have similar results as this research presented.

6.1 Discussion

As opposed to expected, the research shows that Finnish AI technology in SCM field has obstacles and Finnish large-scale companies have not implemented possible AI technology. The generalisation of the results is limited due to lack of respondents. Some companies might have implemented sophisticated AI technology but as results show, many companies have threshold to implement.

Even though the results show that companies do not use sophisticated AI in their operations, they have good understanding and will to develop AI in the future. One reason for lack of responses might be the protection of immaterial rights. If they have plans for AI and they want a competitive advantage in the market, they may not want to share it with others. External operator of AI can only offer same possibilities for all customers and that does not bring competitive advantage. If companies use external operator, the collection of big data might suffer. The main component of AI is big data and with internal

decisions and abilities to collect the data in right way leads to better AI solutions. Companies in the highly competitive market areas must consider do they want same solutions what their competitors could use or do they want to implement something new.

If the company does not operate in highly competitive areas, they must consider many other perspectives to increase revenue, reliability, and sustainability while it is a topical subject today. AI can produce many solutions for the SC problems if the companies could be more open-minded and willing to make a change. Money is usually the problem for these kinds of implementations and companies want to examine the AI carefully and wait until someone else does the game movement. It follows same pace as price competition. Someone decreases the prices, other follows.

According to research made by Prime Minister's Office (2019), they examined skilled employees in data-analytics and AI through LinkedIn. They search keywords in their profiles and the keywords were AI, machine learning, analytics, and data. Comparing companies' employees with the keywords in their profiles to the profiles without the keywords, in six different companies percentage value sets as following: Finnair 0,54%, UPM 0,52%, Kone 0,26%, Outokumpu 0,3%, SOK 0,83% and Kesko 0,59%. Values are not impressive but due to narrowness of the data and distortions in LinkedIn information, the results must be viewed with prudence. (Prime Minister's Office, 2019) However, these percentage values reflect that companies' employees with AI and data-analytics knowledge is only a fraction of total organisation. This supports the difficultness of data collection and lack of respondents because right people were hard to reach.

6.2 Future Research Suggestions

The primary suggestion for future research could wait until quantum computers become more common and are usable for companies. They can exploit it to make more accurate calculations because AI needs a lot processing power. Also, when quantum computers become more common, AI solutions can develop more intelligence.

According to research made by Ministry of Finance (2019), artificial intelligence and robotization become more common in 2020s. It does not happen immediately, but these can be seen in several years. This could be the reason for such immature AI level in this research and the study might be implemented too early. Next implemented research should wait until AI and robotization become more common. Even, media predispose that companies use AI extensively and sophisticated, the future researcher should do broad overview of the topic area.

As results presented narrow scale of AI applications, the future research should be done with SCM professionals and IT-experts because they can combine expertise together and make clear and comprehensive understanding of the topic area. Respondents must have more experience of AI in the future. As discussion presented the number of employees with knowledge of AI and data-analytics is low. The future researcher should find the suitable employees and make data collection by interviewing them. Thus, they can answer for the questions with more knowledge. However, suggestion is to do future research when AI applications are more common, and companies are not at the planning stage. At planning stage, they are afraid to lose competitive advantage if someone steal their idea.

As education for AI functions becomes more common, it produces skilled employees to the job markets. This means more implementations of AI and increasing maturity levels. Even though AI is on the frame all the time, the future research should be done when human and machines interaction become more fluent and data is mature enough to implement sophisticated AI. After all, this study has been done too early and in difficult time, no question about that.

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Appendices

Appendix 1. Survey participation proposal letter (English)

Dear (name),

I contact you because you work as a supply chain professional in a Finnish large-scale company. I need your participation to academic research which purpose is to find out how Finnish large-scale companies are implemented AI solutions in their supply chain management.

You can take a part of survey even if you do not have implemented AI solutions. Participation is important so research results would be as comprehensive as possible.

Survey contain 20 questions and it does not take any longer than 10 minutes of your time. You can participate to the survey via link (Google Docs) below: https://docs.google.com/forms/d/e/1FAIpQLScIB3B0SAHc3gNzzavNoZrYiN-WNO0vXG3f1CKvmXxb3KkI01w/viewform?usp=sf_link

If you want to ask anything about the survey, you can contact to e-mail address b112822@student.uwasa.fi or directly respond for this message.

Thank you in advance!

Kind regards,
Pekka Pasonen (MSc student)
University of Vaasa
The School of Technology and Innovations
Industrial Management

Appendix 2. Survey participation proposal letter (Finnish)

Hei (nimi),

Otan yhteyttä, sillä työskentelette toimitusketjun ammattilaisena suomalaisessa suuryrityksessä ja tarvitsisin osallistumistanne akateemiseen tutkimukseen.
Tarkoituksena on kartoittaa, miten suomalaiset suuryritykset ovat lähteneet mukaan tekoälyllisiin ratkaisuihin toimitusketjun hallinnassa.

Voitte osallistua tutkimukseen, vaikka ette olisi ottanut tekoälyratkaisuja käyttöön. Osallistumisesi tutkimukseen olisi tärkeää, jotta tutkimustulokset olisivat mahdollisimman kattavat.

Kysely koostuu yhteensä 20 kysymyksestä ja tämä ei vie kauempaa kuin 10 minuuttia ajastasi. Osallistuminen tapahtuu alla olevan linkin (Google Docs) kautta: https://docs.google.com/forms/d/e/1FAIpQLScIB3B0SAHc3gNzzavNoZrYiN-WNO0vXG3f1CKvmXxb3KkI01w/viewform?usp=sf_link

Mikäli sinulla tulee kysyttävää kyselystä tai hankaluuksia päästä kyselyyn, otathan yhteyttä sähköpostiosoitteeseen b112822@student.uwasa.fi tai vastaamalla tähän viestiin.

Kiitos paljon jo etukäteen!

Ystävällisin terveisin,
Pekka Pasonen (Maisteriopiskelija)
Vaasan yliopisto
Tekniikan ja innovaatiojohtamisen yksikkö
Tuotantotalous

Appendix 4. Survey form (English)

Occupational title.

Employer (will not be published).

Work experience in SCM field.

Work experience in AI field.

1. Does your company use AI to manage the supply chain?
2. How important do you feel AI to manage the supply chain operations and every-day working?
3. Do you exploit AI across internal borders in a supply chain network?
4. Does AI make decisions behalf of employees?
5. What kinds of decisions does AI make in your supply chain?
6. How often do you have to monitor decisions made by AI?
7. Will you develop supply chain operations by AI in the next five years?
8. Does your system collect big data on supply chain operations? (Big data: large and unsystematic data masses)
9. How much do you think AI would add value to managing the supply chain?
10. How much would you see AI influencing the flow of information between the supply chain networks?
11. Do you think that AI produces transparency to supply chain processes in your company?
12. Do you use spreadsheets in supply chain operations (e.g. Microsoft Excel) to for-warding information?
13. Choose the most appropriate option from your company's AI know-how level of supply chain.
14. What kinds of tasks AI performing?
15. At what different stages of the supply chain does the work produced by AI show up?
16. What kind of AI do you use to control the supply chain? (e.g. robotics, machine learning, etc.)

Appendix 3. Survey form (Finnish)

Ammattinimike.

Työnantaja (ei julkaista).

Työkokemus toimitusketjun työtehtävissä.

Työkokemus tekoälyyn liittyvissä tehtävissä.

1. Käytetäänkö yrityksessänne tekoälyä toimitusketjun hallinnassa?
2. Kuinka tärkeäksi koet tekoälyn toimitusketjun hallinnassa ja jokapäiväisessä työskentelyssä?
3. Hyödynnättekö tekoälyä yli sisäisten rajojen toimitusketjuverkostossa?
4. Tekeekö tekoäly päätöksiä työntekijöiden puolesta?
5. Millaisia päätöksiä tekoäly tekee toimitusketjussanne?
6. Kuinka usein joudutte valvomaan tekoälyn tekemiä päätöksiä?
7. Tuletteko kehittämään toimitusketjun toimintoja tekoälyllä seuraavan viiden vuoden aikana?
8. Kerääkö järjestelmänne big dataa toimitusketjun toiminnoista? (Big data: suuria ja järjestelemättömiä tietomassoja)
9. Kuinka paljon tekoäly mielestänne tuottaisi lisäarvoa toimitusketjun hallinnoimiselle?
10. Kuinka paljon näkisitte tekoälyn vaikuttavan toimitusketjuverkoston välisen informaation kulkuun?
11. Tuottaako tekoäly mielestänne läpinäkyvyyttä toimitusketjun prosesseihin yrityksessänne?
12. Käytättekö toimitusketjun hallinnassa taulukkolaskentaa (esim. Microsoft Excel) informaation eteenpäin välittämisessä?
13. Valitse sopivin vaihtoehto yrityksenne tekoälyn tietotaitotasosta toimitusketjun osalta.
14. Minkälaisia tehtäviä tekoäly suorittaa?
15. Missä eri vaiheissa toimitusketjua tekoälyn tuottama työ näkyy?
16. Minkälaista tekoälyä käytätte toimitusketjun hallinnassa? (esimerkiksi robotiikka, koneoppiminen jne.)

Appendix 4. Interview questions (English)

- Occupational title.
- Experience of SCM and AI.
- What kind of artificial intelligence you exploit in supply chain management?
- How it accomplishes forecasts and order management? Does the work of artificial intelligence occur anywhere else?
- Have you experienced that artificial intelligence have added value to your supply chain management and how? In which way?
- Do you exploit artificial intelligence across internal borders in supply chain network?
- Does artificial intelligence make decisions on behalf of employees and are those strategical-, tactical- or operational decisions?
- How often you must monitor the artificial intelligence? Daily, weekly, or how many times?
- Where you can see your company at this point in this AI-based automation level figure? (Figure 5. AI-based automation level)
- Which of the following describes the best your knowledge of artificial intelligence? (Table 2. AI maturity model)
- Do you have the will to develop it and do you see the potential? And will you develop it in next five years? Have you clear vision how you going to develop it?
- Do you have forecasting and ordering optimization happen in real time? Is it real time optimization or what kind of cycle you use?
- Is the concept gamification familiar?" and "Have you talked about it in your company?
- Have your company outsourced artificial intelligence solutions?