Arttu Hietikko-Kaukola

Material Handling Industry Review

Current state, trends, and the future

School of Technology and Innovation
Master's Thesis in Industrial Management
Master of Science in Economics and Business Administration

Vaasa 2021

UNIVERSITY OF VAASA
School of Technology and Innovation
Author: Arttu Hietikko-Kaukola
Title of the Thesis: Material Handling Industry Review: Current state, trends, and the future
Degree: Master of Science in Economics and Business Administration
Programme: Industrial Management
Supervisor: Petri Helo
Year: 2021 **Number of pages:** 80

ABSTRACT:
The material handling industry has developed significantly over the decades due to constant progress in material handling technologies. The importance of material handling for organizations is pointed out by the fact that it includes all movement of material within production environments. Sufficient implementation of material handling can have several positive impacts for organizations and especially in terms of overall efficiency.

This thesis discusses the state and advancements of the material handling industry locally in Suupohja region, regionally in Finland and also globally in the worldwide markets. The thesis was commissioned for the needs of several Suupohja region's material handling companies in 2021 with the aim of getting a good overall picture about the status of the industry. The idea is to find out who are the key players in the industry, what kind of products they manufacture and how they are doing based on their financial figures, which were gathered from Asiakastieto.fi. Especially the Finnish material handling companies are studied thoroughly and the results about how they are doing are presented in table and figure form. The thesis also aims to discover what are the most common and most used technologies and equipment in the industry now and in the future with the findings being showcased in the literature review section. The goal is also to find out how substantial the material handling market is overall and how it is spread out globally. The thesis also includes a questionnaire about the state of the industry, which was conducted for several Finnish companies working in the industry and is presented in the results section of the thesis.

The thesis is conducted by combining both qualitative and quantitative research methods in addition to a theoretical approach. The findings of the thesis reveal that new forces of technology are taking material handling industry by storm. Organizations are aiming to implement many of the Industry 4.0 practices into their operation, which can be seen from the adoption rates of the different technologies that are presented in the literature review. Automatic or semi-automatic material handling methods are taking over the traditional manual operations and methods while also providing a competitive edge. Overall, the material handling industry is expected to have a steady growth in the upcoming years globally with the Asia Pacific region being the leading force in the industry.

KEYWORDS: material handling, material handling companies, material handling equipment, material handling industry, industry 4.0

VAASAN YLIOPISTO
Tekniikan ja innovaatiojohtamisen akateeminen yksikkö
Tekijä: Arttu Hietikko-Kaukola
Tutkielman nimi: Materiaalinkäsittelyalan katsaus: Nykytila, kehitys ja tulevaisuus
Tutkinto: Kauppatieteiden maisteri
Oppiaine: Tuotantotalous
Työn ohjaaja: Petri Helo
Valmistumisvuosi: 2021 **Sivumäärä:** 80

TIIVISTELMÄ:
Materiaalinkäsittelyala on kehittynyt huomattavasti vuosikymmenten saatossa erityisesti materiaalinkäsittelyteknologioiden jatkuvan kehityksen johdosta. Materiaalinkäsittelyn tärkeyttä yrityksille korostaa se, että termi sisältää kaiken materiaalin kuljettamisen tuotantotilojen sisällä. Materiaalinkäsittelyn riittävällä käyttöönotolla ja toimeenpanolla voi olla useita positiivisia vaikutuksia yrityksille erityisesti yleisen tehokkuuden suhteen.

Tämä tutkielma tarkastelee materiaalinkäsittelyalan tilaa ja kehitystä paikallisesti Suupohjan seudulla, alueellisesti Suomessa ja globaalisti kansainvälisillä markkinoilla. Tutkielma toteutettiin toimeksiantona useiden Suupohjan seudun materiaalinkäsittelyalan yritysten tarpeisiin vuonna 2021, päätarkoituksena saada selvä kokonaiskuva alan tilanteesta. Tutkielman tarkoituksena on selvittää ketkä ovat alan suurimpia toimijoita, minkälaisia tuotteita he valmistavat ja miten he ovat pärjänneet Asiakastieto.fi sivustolta kerättyjen taloudellisten lukujen perusteella. Tutkielmassa tutkitaan erityisesti suomalaisia materiaalinkäsittelyalan yrityksiä ja niiden suoriutumista kuvataan lukujen muodossa taulukoissa ja kuvioissa. Tutkielman tavoitteena on myös kirjallisuuskatsauksessa selvittää, mitkä ovat yleisimmät ja suosituimmat alalla käytettävät teknologiat ja laitteet nyt ja tulevaisuudessa. Tutkielma pyrkii lisäksi selvittämään, miten huomattava materiaalinkäsittelyala on kokonaisuudessaan ja miten se on levinnyt maailmanlaajuisesti. Tutkielmaan kuuluu myös kyselylomake alan tilaan liittyen, joka toteutettiin useille suomalaisille materiaalinkäsittelyn parissa työskenteleville yrityksille ja joka esitetään tutkielman tuloksissa.

Tutkielma on toteutettu yhdistämällä laadullisia ja määrällisiä tutkimusmenetelmiä teoreettisen lähestymistavan lisäksi. Tutkielman tuloksista käy ilmi, että uudet teknologiat valtaavat jatkuvasti suurempaa osuutta materiaalinkäsittelyalasta. Yritykset pyrkivät lisäämään Teollisuus 4.0 käsitteen käytäntöjä omassa toiminnassaan, joka on nähtävissä kirjallisuuskatsauksessa esitettävien teknologioiden käytön levinneisyydestä. Automaattiset ja puoliautomaattiset materiaalinkäsittelymenetelmät ovat ottamassa perinteisten manuaalisten menetelmien paikan ja tarjoavat samalla kilpailuetua. Kaiken kaikkiaan materiaalinkäsittelyalan odotetaan kasvavan tasaisesti globaalista näkökulmasta tulevina vuosina Aasian ja Tyynenmeren alueen yritysten toimiessa alan johtavana voimana.

AVAINSANAT: materiaalinkäsittely, materiaalinkäsittelyala, materiaalinkäsittelylaitteet, materiaalinkäsittelyalan yritykset, teollisuus 4.0

Table of contents

Figures

Tables

Abbreviations

AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AR	Augmented Reality
CAGR	Compound Annual Growth Rate
CO_2	Carbon dioxide
CPS	Cyper-Physical System
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
IoT	Internet of Things
MHI	Material Handling Industry
PLC	Programmable Logic Controller
QR code	Quick Response code
R&D	Research and Development
RFID	Radio Frequency Identification
RPP	Revenue per Person
VR	Virtual Reality

1 Introduction

The main purpose of this thesis is to highlight the importance of material handling functions, the equipment that are used in material handling and how the industry is doing in general on a global scale and even more specifically in Finland. This thesis was commissioned for several Suupohja region material handling companies during 2021. Similar, smaller research has been conducted earlier in 2009. The background, scope and objectives of the study and the structure of the thesis are further discussed below.

1.1 Background

Material handling has an important role in logistics and manufacturing functions of each organization as it includes all the material movements in a production environment. It is a widely researched topic and an industry that is closely followed by associations such as MHI.org, which promotes the industry at a large scale and provides up-to-date information regarding the advancements, trends and competitive forces in the industry. The technologies in terms of material handling are constantly evolving and changing the industry as a whole.

1.2 Scope and objectives of the study

The aim of this thesis is to provide a review on the material handling industry for the case companies' needs. The goal is to find out what is happening in the industry locally in Suupohja region, regionally in Finland and globally in worldwide markets. One of the main focuses is to introduce the companies working in the material handling industry and determine how they have been doing based on financial numbers such as revenue and operating income. Material handling equipment, technologies and manufactured products are also showcased. The overall goal is to provide an outlook on the past, present and the future of the material handling industry. The research questions of the thesis are 1) How big is the material handling market and how is it spread globally? 2) Who are the key players in the industry, what kind of products they manufacture and how

they have been doing based on their financial figures? 3) What are the equipment and technologies used in the industry now and in the future? 4) What should the Suupohja region companies do to remain competitive in the industry?

The industry in general, material handling markets, and technologies are researched on a worldwide basis and are presented in the second section of the study. The results part focuses mainly on the companies working in the industry and determining how they have been doing in the last few years. TOP20 material handling companies worldwide are showcased, but closer attention is paid to the Finnish companies. In the study all the data of the companies was gathered into an Excel spreadsheet and the results are showcased in table and figure form in the study. In the spreadsheet, information such as revenue, revenue growth percentage, number of personnel, RPP, operating income, operating income growth percentage and location of the company's headquarters are presented. The spreadsheet was also sent to all the Suupohja companies participating in the study. A questionnaire related to the industry was also conducted and sent to some of the Finnish material handling companies. The answers were gathered via telephone interviews and a summary of them is presented in the results section of the study.

During the writing process two workshop meetings were organized to determine the goals and objectives for the study together with some of the case companies and other participants of the research group. The point of the discussion was also to get other points of view for the purpose of the study and what is wanted to be achieved in the research. The findings of the study were presented in the workshop meetings and the company list of the Finnish actors in the industry was approved by the participants.

1.3 Structure of the thesis

This thesis is constructed of five main sections which are presented in Figure 1. The goal is to provide systematic research on the topic. The first section provides an introduction on the research topic in general. Background information for the thesis is described and the case companies are introduced in a suitable manner. The research questions and

objectives that the thesis tries to answer and solve are presented. Scope of the study, data collection methods and the way of result presentation are also described.

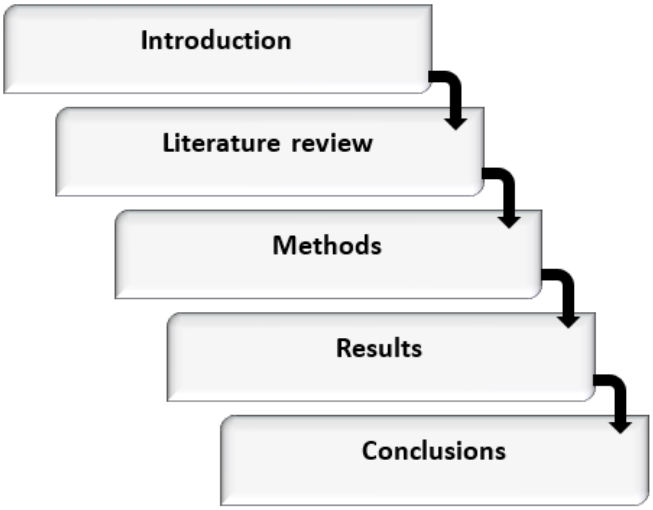


Figure 1. Main structure of the thesis.

The second section provides the literature review on the topic. This section helps the reader to get a better idea about the topic that is researched by explaining the terms and concepts that are discussed later in the thesis as well. Some of the research questions are answered in this section as the information regarding the state of the industry, technologies and markets are already available and cannot be presented as the writer's own results. The section is divided into several subsections to keep the framework clear and to help the reader in understanding the context and importance of each individual section. The subsections focus on material handling as a term, the technologies in material handling in 2020's and material handling markets in general. Different types of material handling equipment are also presented as mechanical, half-automatic and automatic material handling equipment are all talked about separately.

The third section focuses on the research methods and methodology that are used in the thesis to answer the research questions. The data collection methods and analyzing tools are introduced and the reasoning for choosing the specific approaches are

explained. Attention is also paid to the degree in which the research can be considered trustworthy and legitimate.

The fourth section presents the results to the research questions and objectives that were not yet answered in the literature review. These are mainly the financial figures of the companies worldwide and especially in Finland, which are used to determine how the companies and industry have been doing. Finnish companies are put into several ranges based on their revenue and best and worst performers are brought up. The summary part concludes the results of the companies in general. Main products, most common material types that the products transport and customer references of some of the companies are also presented. The results of the questionnaire conducted for a few of the Finnish material companies are also presented in this section.

The final section concludes the findings of the study and presents them in a summarized form, from which the main points can be found easily. The idea is that by having a look at the concluding section, the reader is able to get an idea about what was achieved in the research. Suggestions for the companies to remain competitive in the industry are presented, as well as future research possibilities.

2 Literature review

The literature review section tries to elaborate on the theoretical framework of the study and provides an explanation to most of the terms and concepts that are needed to get a better understanding about the topic and the goals of the study in general. Material handling, material management and all of the industrial revolutions are discussed. Material handling equipment, trends and technologies, as well as the material handling market are also gone through in the subsections.

2.1 Material handling

Simply put, material handling can be described as the packing, moving, and unloading of materials. There are various kinds of material handling equipment that can be used to perform material handling activities safely, although this study focuses on the usage and types of material handling that are used in an industrial environment. Material handling is needed in every type of industry that contains some sort of construction or manufacturing work. In this type of work the material needs to be handled in different stages of the supply chain from start to finish. Material can also be handled in different kinds of forms, such as in a raw material form, as an intermediate good or as a finalized product. (Ray, 2008)

According to Stephens and Meyers (2013), material handling can be described as the process of getting the correct materials to the right location, at the right time and in the right number within a production environment. The material also has to be in the right state and condition in order to reduce costs of manufacturing. By improving the flow of material with the help of material handling equipment, companies are able to cut their production costs considerably. Thanks to the continuously advancing equipment, a lot of industrial problems can be eliminated and the need for humans to perform tasks involving physical drudgery are also diminishing. No other area in industrial history has seen more advancement than the use of material processing and handling equipment. This has been helped by the fact that these days material handling systems can effectively be

integrated with cutting-edge technology for example in automated inspection systems and in automated data collection equipment. (Stephens & Meyers, 2013)

The goal of efficient material handling is to support production processes and help them run smoothly. Material handling also causes expenses for a company, which is why the need for it should be minimized as much as possible. Material handling in itself is not part of the production process, as it does not contribute to the product's worth. The need for material handling and the material handling type that is used should be deliberately planned to suit the needed application. Many factors, such as the weight, quantity and throughput of material have an effect on which material handling method should be used. Manual material handling can be costly, which is why automated solutions have become very popular. (Ray, 2008) Although material can be moved with different kind of methods, the material handling process also involves various storing options. The possibilities for viable solutions are endless and the correct solution should be determined by weighing the costs of the several options. To point out the importance of safety in material handling, it has been estimated that the handling of materials is responsible for over half of all industrial accidents. The importance of cutting the material handling costs is also emphasized by the fact that material handling generates about 50 percent of a company's overall operating expenses on average and depending on the specific industry the number can be even higher. (Stephens & Meyers, 2013) The different types of material handling methods and equipment are introduced in subsection 2.2.

When looking at the bigger concept of material management, the objectives can be divided into two separate categories, which are the primary (direct) objectives and secondary (indirect) objectives. Primary objectives normally lead to the completion of any of the other company's overall objectives, whereas secondary objectives occur as a result of the materials department supporting other departments in the company. The primary objectives are concerned with reaching, for example, high inventory turnover, low prices and salary costs, consistent quality, and fond relations with the suppliers. On the other hand, secondary objectives include factors such as standardization, price

forecasting and the improvement of existing products as well as creating entirely new products and materials. (Bhat, 2009) These are mostly the same as to what can be achieved with well-designed material handling systems. Like every other solution, material handling also has the same negative aspects, such as relatively high capital costs, restricted flexibility after implementation, the need for maintenance and the stoppages to the entire production system if an integrated material handling system has a failure. (Ray, 2008)

The overall scope of material management includes several different activities such as planning, procuring, controlling, storing, handling, distribution and transportation control. In the planning activity, the idea is to find out which material is needed in which location and to schedule the purchasing of that material, which is then performed in the procuring phase. Controlling aims to make sure that the agreed schedules are adhered and needed data is gathered throughout the process, whereas storing includes the inspection, handling and warehousing of incoming and finished goods. The handling activity involves packaging and moving the materials to the correct destination, and the distribution activity takes care of the finished products by either warehousing, packing or by sending them to the customer. The final activity is the transportation control, which is very important as it takes care of the commodity rates, routing standards, carrier selections and dispatching of shipments. The overall material management concept is shown in Figure 2. (Bhat, 2009)

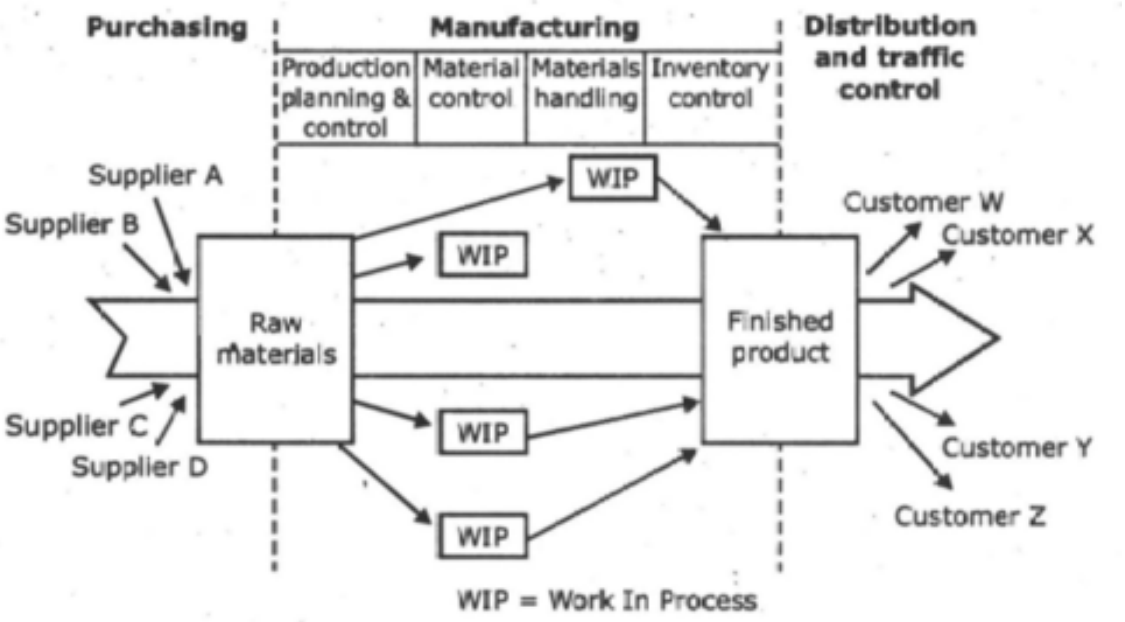


Figure 2. The concept of material management (Bhat, 2009).

2.2 Material handling equipment

This subsection focuses on introducing different types and variations of material handling equipment. The selection of the most appropriate material handling equipment is essential for each organization as it is a way of getting rid of drudgery work and reducing production costs. In total, the material handling equipment list has over 500 different equipment types and as there are also several kinds of sizes, models and brands, the total number of material handling equipment to choose from is several thousands. Careful cost comparison between the different material handling equipment is needed to choose the best available option for an organizations' needs. (Stephens & Meyers, 2013)

Material handling equipment can be generally classified into three separate categories based on the way in which they function. These categories are mechanical, semi-automatic and automatic material handling. Mechanical material handling is traditionally understood as material handling performed with the help of personnel labour and possible work machinery. In this case automation is used only to some extent or not at all. Mechanical material handling equipment includes all sorts of pallet jacks, stacking wagons,

forklifts, conveyors, carriers and bridge cranes. Forklift is the most common material handling equipment due to its flexible working characteristics. Forklifts can handle both vertical and horizontal lifts and the availability of several grabbing attachments allows lifting materials in various shapes, although it is best suited for lifting parcelled goods. Forklifts are also fairly inexpensive, and their lifting capacities are versatile. The biggest restrictions regarding forklifts are that they require even floor surface and can be ineffective in transporting bulk material. (Hokkanen, Karhunen, & Luukkainen, 2011) An electric forklift by Caterpillar is presented in Figure 3.

Figure 3. EP16-20A(C)N Electric Forklift (CAT Lift Trucks, 2021).

Conveyors are normally electric motor-powered devices with a separate load transfer body, and they have a frame of the length of the transportation route. Generally, conveyors have a fixed structure, and they can be either vertical, ascending or descending based on the location where they are installed. Conveyors allow effective material handling due to their speed and the capability of installing them to either the roof, wall or floor. It is a good option when large amounts of material need to be transferred from a fixed point to another or between different floors. The drawbacks with conveyors are that they cannot be easily modified after installation, which is why careful forward planning is required to avoid extra costs. The safety aspects of conveyors are also not as good as with many of the other material handling equipment and extra attention needs to be paid when working near them. The most important types of conveyors are belt, slat,

chain, roll and pneumatic conveyors and elevators. Spiral and vibratory conveyors are also well suited for handling fine-grained material in large quantities. Other equipment that can be categorized under the mechanical material handling equipment are various types of bridge cranes, boom cranes, roller paths and freight elevators. (Hokkanen et al., 2011) Figure 4 shows a motorized roller conveyor.

Figure 4. Motorized roller conveyor by elcom (elcom, 2021).

The most common semi-automatic or automatic material handling equipment are robotics, AGVs, automatic sorting and paternoster elevators. AGVs are very similar to the traditional mechanized system with the exception that no forklift operator is needed. They are able to move independently through a specific path by following magnetic strips or induction cabling embedded in the floor. The latter option is a good choice only when the runway will stay the same throughout its operation as it is hard to make modifications to the embedded cabling. AGV operation can also be carried out by either laser control or magnetic points, which is called free location determination. In this case the available route map is fed to the vehicle, and it is able to determine its location due to the steering angles and the rotation speed of its wheels. This type of location determination can be inaccurate to some extent, which is why a "repair system" is normally needed. It can be implemented by either combining laser control and mirror reflectors or installing a magnetic network to the floor and detectors to the vehicles that notice when each magnet is passed. Pick-to-AGV is a common term in semi-automatic material handling, and it means that a worker collects items for the AGVs that transport them to

the next destination. (Hokkanen et al., 2011) Figure 5 shows a pallet stacking AGV by Dematic.

Figure 5. Pallet stacking AGV by Dematic (Dematic, 2018).

The most common uses of robotics in logistic applications related to material handling are equipment like automatic packing machines and automatic load dischargers. These types of solutions can be programmed to have various trajectories and functions and their biggest benefits are precision, speed and independence. In material handling, several procedures are needed and the differences in the size and shape of the material can be large, which can be challenging. Automated Storing/Retrieving Systems (AS/RS) and shelving houses are also popular solutions as they help organizations in reaching higher efficiency and reducing labour costs. These fully automated warehouses are computer-controlled and have precise identification technology for the stored material and the shelving and collecting is performed with automated shelf carriages. (Hokkanen et al., 2011)

The total amount of material handling equipment and the types that are used is massive, which is why it is hard to mention all of them or go into detail about their design and capabilities. Because of this, material handling equipment are often classified into some of the basic types of equipment. Ray (2008) categorizes material handling equipment

into the seven different categories introduced below. A few examples of each category are written inside the brackets.

- Industrial vehicles/trucks (forklift, hand truck, lift table)
- Conveyors (chain, roller, pneumatic)
- Hoists, elevators and cranes (winch, bucket elevator, bridge crane)
- Bulk and miscellaneous handling equipment (ship loader, excavator, stacker)
- Robotic handling systems (packing machine, loading machine)
- Containers and supports (shipping container, liquid container, pallet)
- Auxiliary equipment (crane and forklift attachments, positioner)

2.3 Effects of industrial revolutions on material handling

The material handling systems of today are still significantly impacted by the advancements in automation technology all the way from the 1970s, when most systems were able to be used only in manual operation. Automated material handling systems and their quality, productivity and reliability developed significantly in the last thirty years and when talking about the overall material handling process, the decision-making is often being spread across many systems, such as ERP and warehouse management systems. Because of this, the need for reliable, adjustable, responsive and easily adaptable systems that are able to comply with constantly changing demands and processes is continuously growing. The importance of factors such as scalability, resource efficiency, safety, reconfigurability and self-adaptability are also pointed out when talking about the desirable attributes for material handling systems of the future. (Furmans, Seibold, & Trenkle, 2018)

In total, there are four industrial revolutions that have been witnessed over the years. These different industrial revolutions and their characteristics are presented in Figure 6. (Spectral Engines, 2018) The first industrial revolution lasted from the end of the 18th to the beginning of the 19th century with the most significant changes occurring as a result

of mechanization. This led to agriculture beginning to be displaced as the backbone of society economy and the invention of the steam engine led to the possibility of producing new sort of energy. The second industrial revolution began at the end of the 19th century and is often considered as the most significant one of the revolutions because of the several inventions that were made. Major technical breakthroughs aided the development of new sources of energy, such as oil, gas and electricity. Inventions like the internal combustion engine, chemical synthesis and communication methods such as telephone were all discovered during the second industrial revolution. The third industrial revolution occurred at the second half of the 20th century and introduced another new energy source in nuclear energy. Telecommunications, electronics and computers all arose during the third revolution as well. The level of automation started to rise in general due to two significant innovations in PLCs and robots. (institute of Entrepreneurship Development, 2019)

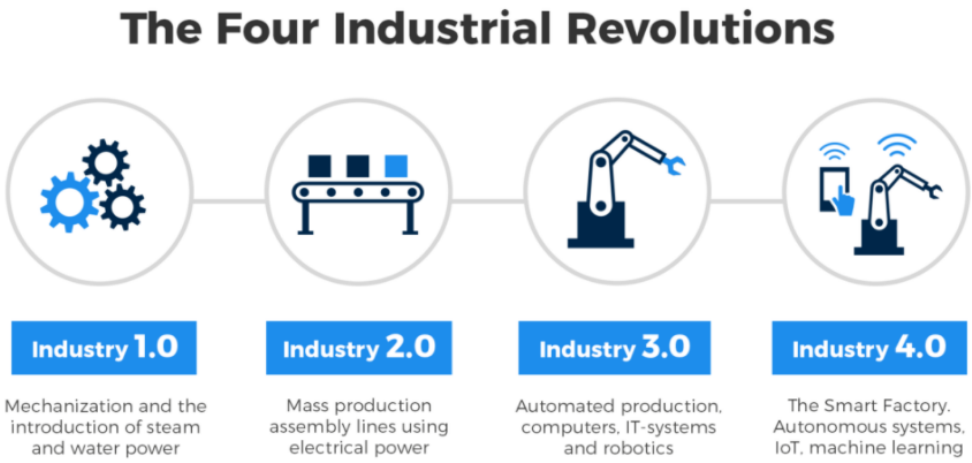


Figure 6. The industrial revolutions to date (Spectral Engines, 2018).

The fourth industrial revolution, which is also known by the term Industry 4.0 was first introduced in Germany in 2011. Industry 4.0 has started to gain increasing interest in material handling over the decade and companies are in increasing manner trying to implement the practices of it. Industry 4.0 consists of characteristics such as automation, adaption, digitalization, customization and optimization, which are crucial when aiming to achieve higher levels of productivity and operational efficiency. The main goal behind

utilizing Industry 4.0 practices is the need for building manufacturing facilities that are "smart", capable of adapting to needed changes and able to use resources effectively, as well as to be able to function at a high level of autonomy with minimal need for human interference. Logistics are no longer just the physical activity of delivering goods to the correct destination in the right condition and quantity, as nowadays topics related to IoT are closely linked to it and are taken advantage of more effectively. (Efthymiou & Ponis, 2019) Figure 7 presents the most important technologies that are according to Saturno, Pertel and Deschamps (2017) required to properly execute Industry 4.0 practices. The authors also mention that these technologies should fulfil the requirements that are derived also from current architectures' functionality. The requirements are needed to provide system flexibility, consistency and connectivity between different systems. When correctly implemented, Industry 4.0 can bring increased robustness and compliance with high quality standards related to the phases of production, such as planning, engineering, manufacturing and logistics. (Saturno, Pertel, & Deschamps, 2017)

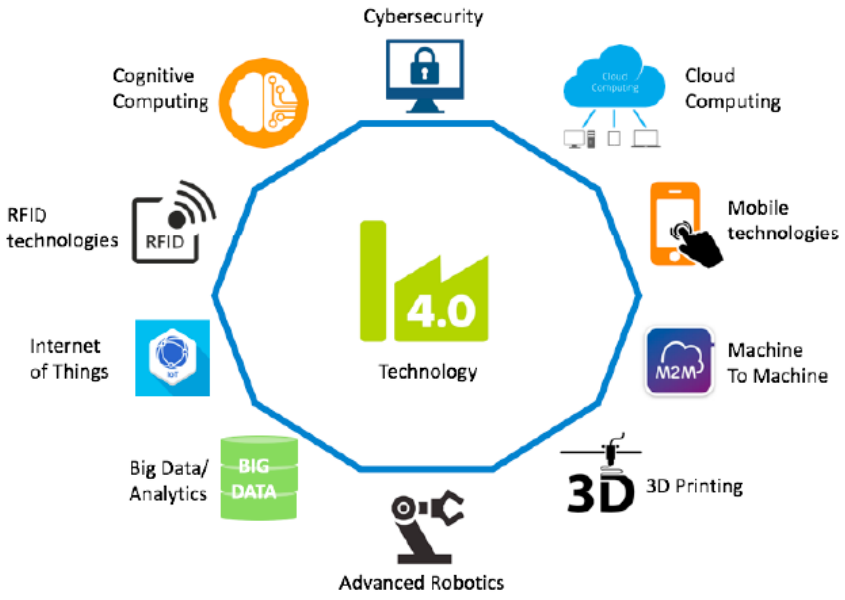


Figure 7. The technological pillars of Industry 4.0 (Saturno et al., 2017).

The industrial and manufacturing sectors pursuit for automation has been a well-known fact for quite a while as companies are trying to develop systems and technologies that

increase productivity, cut down human error and are able to create a positive return on investment. From a historical point of view automation has required long deployment times, large capital investments and system integrators. This has led to problems with launching new products as the factories are often not as adaptable or configurable as the manufactured products. Transformation towards Industry 4.0 requires finding the correct tools at the correct time and place and utilizing them in the best possible way for the needs of the organization. The biggest difference in Industry 4.0 philosophy is that everything is data-driven and digitally enabled. These differences between the 1st generation of automation and Industry 4.0 are further showcased in Figure 8. (ABI Research, 2019)

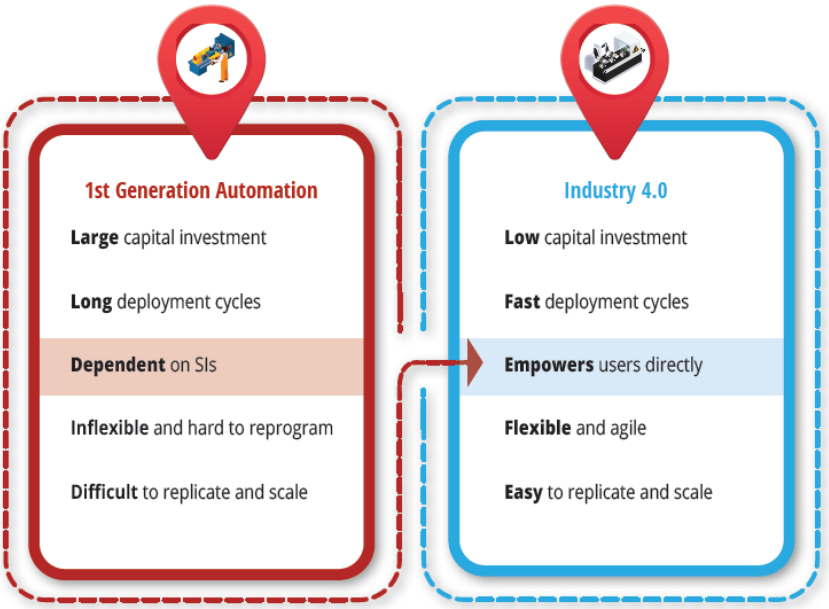


Figure 8. The differences between the first stage of generation automation and Industry 4.0 (ABI Research, 2019).

Industry 5.0 is a fairly new concept that was first introduced in the beginning of 2020's and has been studied especially by the European Commission. The concept derives from the principles of Industry 4.0 and emphasizes the importance of innovation and research in assisting industries in providing long-term service to mankind within planetary limitations. The main idea is to shift away from focusing only on profit-driven production of goods or services. The wellbeing of workers is also put into the centre of manufacturing

processes and new technologies are used to provide prosperity beyond jobs and growth while preserving the environment. The goals of Industry 5.0 can be described by the wider purpose elements presented in Figure 9. (Breque, De Nul, & Petridis, 2021)

Figure 9. Three core elements of wider purpose in Industry 5.0 (Breque et al., 2021).

Human-centric approach focuses on human needs at the centre of the manufacturing process. The approach wants to find out what new technologies are able to do for us rather than focusing on what we can do with the new technology. Manufacturing processes are also being adapted for the workers by the use of technology rather than telling the workers to adapt their skills for the needs of the technology. Human-centric approach also tries to ensure that the use of new sorts of technology does not jeopardize the rights of the worker, such as human dignity and privacy. Sustainability element tries to create processes that allow natural resources to be recycled, re-used and re-purposed to reduce environmental effects and waste. This is done, for example, by lowering energy consumption and greenhouse gases while taking into account the needs of current and future generations. The goals of sustainability will be highly affected by technologies that can help with improving resource efficiency and reducing waste, such as additive manufacturing and AI. The last element is resilience, which focuses on the necessity of improving robustness in industrial manufacturing by equipping it against interruptions and ensuring that it can support vital infrastructure during a crisis situation. These sorts of crisis

situations highlight the vulnerability of the existing approaches to globalised manufacturing, and they can be, for example, a natural disaster or a pandemic like the COVID-19. (Breque et al., 2021)

2.4 Material handling trends and technologies

In terms of material handling trends and technologies, the technological pillars of Industry 4.0 are the methods that material handling companies are utilizing the most at the moment. The term Industry 4.0 was already explained earlier and as the definition is so broad, this subsection focuses on pointing out some of the most important and most used methods of it in terms of material handling. The technologies, material handling solutions and key machines are also further discussed in the questionnaire part of the thesis in section 4.4 answered by companies working in the industry.

Digitalization and automation are the main terms influencing the material handling of today, basically working as a hypernym for most of the practices and being heavily linked to Industry 4.0 practices. According to Efthymiou and Ponis (2019), Industry 4.0 methods are having a big effect on material handling and logistics in general by being able to integrate technologies into linking devices and processes together. This helps with improving solutions related to efficiency, operational and profitability solutions. By creating solutions that make certain services of products “smart”, companies are able to reduce human intervention in their workflow and freeing humans from unnecessary work. The IoT technologies allow different areas of material handling to be developed and helps with solving problems that traditional supply chains face frequently. (Efthymiou & Ponis, 2019)

Most of the Industry 4.0 practices will transform material handling industry in the future one way or another, and even the smart manufacturing systems of today rely on intelligent devices and machinery. According to Tjahjono, Esplugues, Ares, & Pelaez (2017), technologies such as VR, AR, 3D-Printing and simulation have several positive effects on logistics and material handling in general. On the other hand, technologies like cloud

computing, Big Data Analytics, cybersecurity, RFID and robotics were seen as having both positive and negative implications for businesses. (Tjahjono, Esplugues, Ares, & Pelaez, 2017). Edirisuriya, Weerabahu and Wickramarachchi (2018) highlight five key technological factors that will lead to logistic tasks having complete automation in the future. These factors are RFID and QR-codes, robots and autonomous vehicles, conveyors and sensors as well as smart devices and CPS. (Edirisuriya, Weerabahu, & Wickramarachchi, 2018)

Based on Efthymiou and Ponis (2019), the most important Industry 4.0 application for the needs of material handling is RFID. It offers the possibility of accurate location of products or devices in indoor situations. Sensors can also be added into the warehouse's infrastructure to enhance the tracking possibilities. The term preventive maintenance was also mentioned as being important in factory environments as the overall equipment effectiveness is a main metric for evaluating manufacturing productivity. The use of IoT and especially data analytics are needed to achieve the requirements related to preventive maintenance. When talking about the future of physical activities in material handling like packing and storing, applications and innovations such as robots, CPS, AR, VR and wearable devices were mentioned as the most important ones. The amount of information technologies in material handling equipment is constantly increasing and is allowing the equipment to autonomously know their location, identify themselves and to gather data about their state and the products. Through electronics like phones, tablets, wearables and other AR or VR devices, workers will soon be able to join the IoT system and improve the interaction between human and machine. (Efthymiou & Ponis, 2019)

Managerial and strategic approach in material handling is taken into consideration by Industry 4.0 technologies like simulation, Big Data Analytics and digital twins. Few of these were already mentioned earlier, but their importance should be stated as they are at the centre of attention when talking about methods for gathering information about tasks related to material handling. It is still common that very little data about the

processes is collected, and the data is often accessed by only a small group of people who can decrypt and comprehend domain systems. Material handling equipment and facilities are equipped with sensors and linked to systems that are able to organize the data to create a digital shadow of reality. This helps in predicting potentially dangerous events ahead of time. All in all, it could be said that material handling or logistics is no longer only the physical activity of moving the correct material to the correct place in a timely manner as it has evolved into a key driver of societal and digital transformation mainly due to the Industry 4.0 practices presented earlier. (Efthymiou & Ponis, 2019)

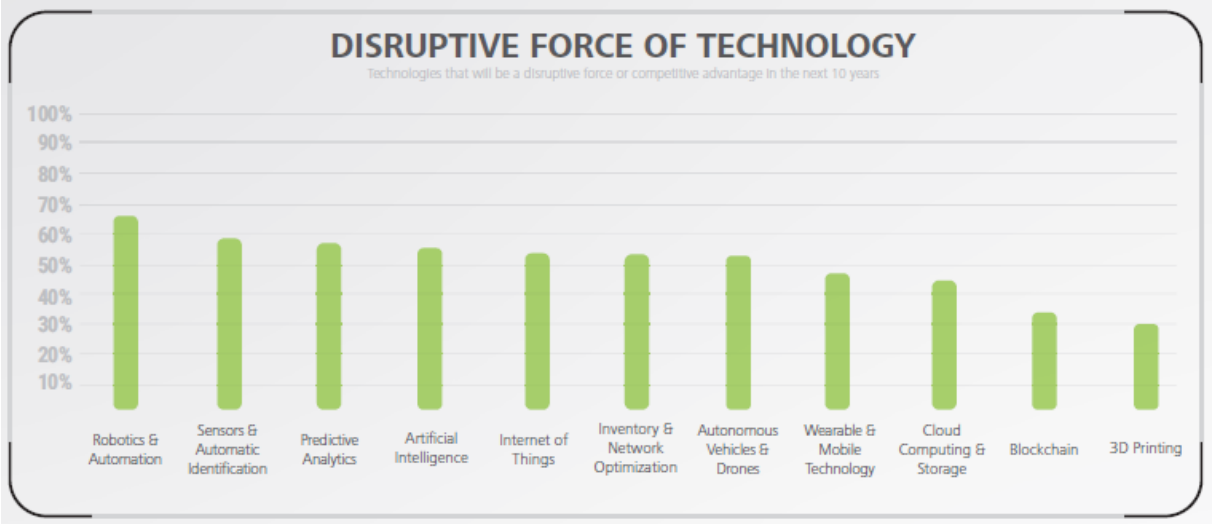


Figure 10. Technologies seen as disruptive forces or competitive advantages in the next 10 years (MHI, 2020).

Figure 10 represents the different technologies based on the degree of competitive advantage that they will present in the next 10 years according to over 1000 respondents from the material handling industry. As can be seen from the figure, there are several major technologies to look out for in the future of the industry. All the 11 technologies presented range in the area of 30%-65% which means that they are considered to be essential and the implementation and investments towards these technologies is expected to increase during the next decade. The projected 5-year adoption rate of the technologies is also expected to be exponentially higher than compared to the usage of

today. The biggest increases expected regarding usage of the technologies on a 5-year period were for technologies like blockchain, AI, AGVs, drones and IoT in general.

Figure 11 shows the adoption rates of the technologies more specifically. As can be seen, the innovations most in use today are related to robotics and automation, sensors and automatic identification, cloud computing and storage, and tools for optimizing inventory and network, whereas blockchain, additive manufacturing, autonomous vehicles and drones, and AI technologies are not yet utilized to such a high extent. For most of the technologies, the growth of the adoption rates is expected to be biggest during the next 1-2 years and slowly declining towards the 6+ year mark. The results of Figures 10 and 11, which showed the disruptive forces of technology and adoption rates of the technologies and also the general consensus of the industry are very much in line in terms of the most common solutions. (MHI, 2021)

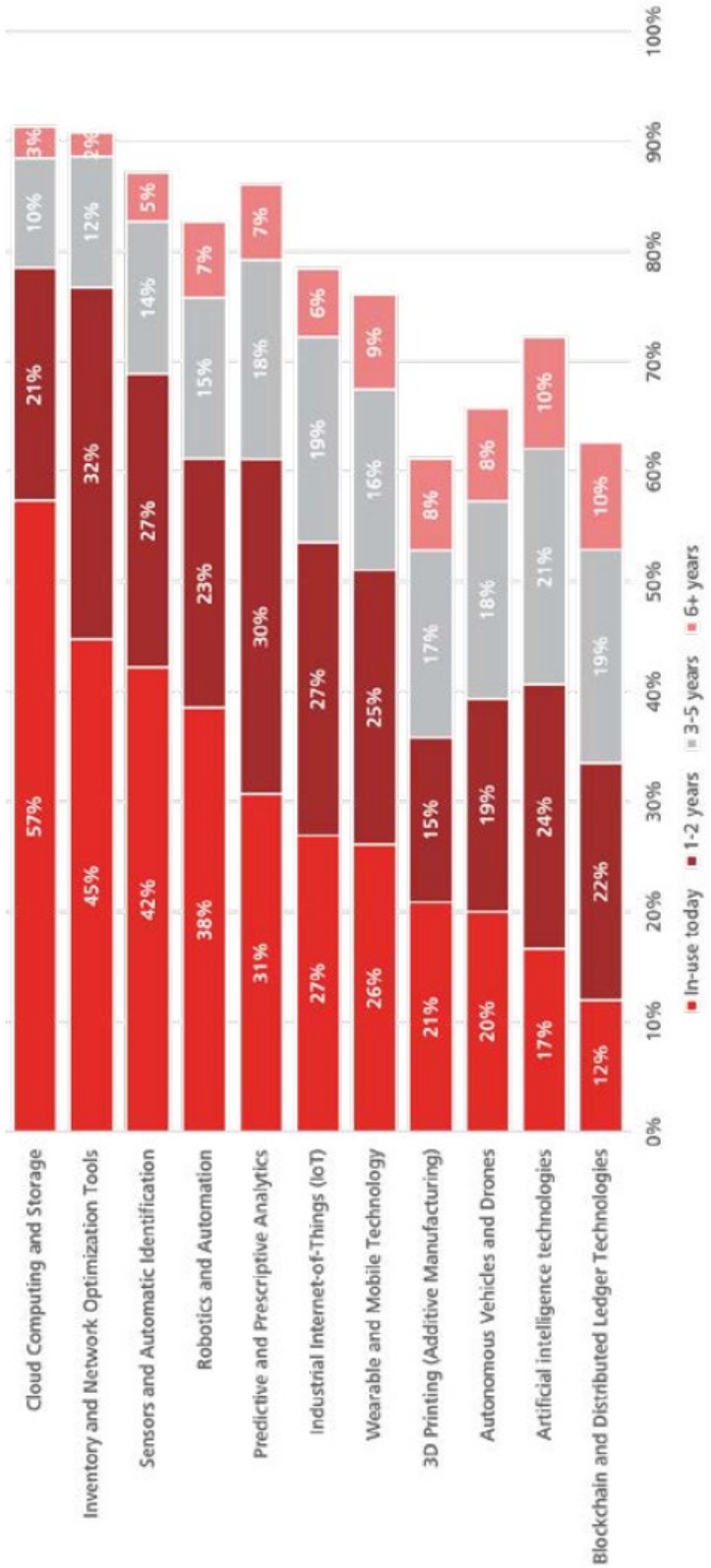


Figure 11. Adoption rates of different technologies (MHI, 2021).

The goal of supply chains is to achieve a high level of flexibility and effectiveness. Unprecetended and disruptive events are expected to become the norm in the future and with the help of digital technologies companies can become more resilient. Companies that invested in innovative technologies for supply chains prior to the COVID-19 crisis were able to respond faster and recover in a shorter time frame. Although digital technology does not solve all of the problems, with the help of the technologies mentioned in this the goals of organizations can become more easily achievable. Figure 12 shows the amount of investments that are predicted towards different sort of products and services during the next three years. (MHI, 2021)

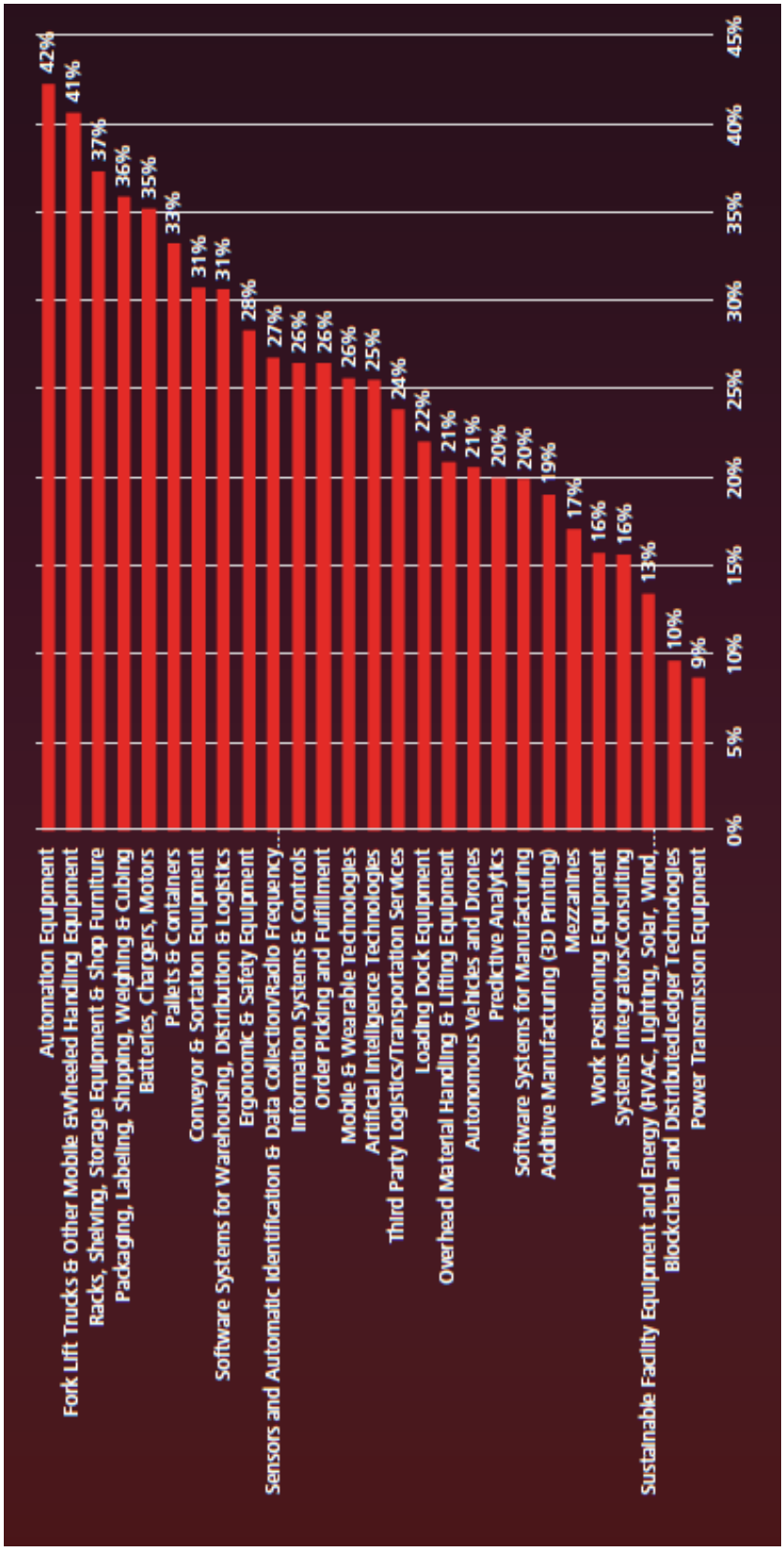


Figure 12. Investments towards different products and services in the next three years (MHI, 2021).

2.5 Material handling market

The material handling equipment market includes all equipment related to, for example, the storage, movement, control, consumption and manufacturing processes. This equipment enables precise and swift movement of material in different volumes. Examples of the different types of equipment were presented earlier in subsection 2.2. This section aims solely on giving an insight on the material handling equipment market. The size, growth and distribution of the market going forward are pointed out. Historical and forecast revenue of the market segments are also provided. The profiling of the key players in the market is showcased separately in subsections 4.1 and 4.2 in the results section. The biggest factors influencing the market growth are the technologies that were presented in subsections 2.3 and 2.4. The forecasts for the industry can vary based on the source that is used, which is why multiple sources are utilized to get the best possible idea of what the mean values for the industry would be. The material handling market has earlier been researched mainly by several market research companies. Figure 13 shows the segmentation of the global material handling equipment market by operation, system type, application and region.

Figure 13. Market segmentation of material handling equipment market (Market Research Future, 2021).

According to an industry report conducted by Global Market Insights (2021), the market size of the material handling equipment industry reached over 140 billion USD in 2020 and for the forecast period from 2021 to 2027 the projected CAGR is expected to be around 6%. This amount of growth will lead to a market size of over 200 billion USD by the end of the forecast period in 2027. The COVID-19 pandemic has impacted the industry negatively in 2020 and 2021 as countries have been in strict lockdowns and investments towards supply chains, expansions and manufacturing facilities have been delayed or completely withdrawn. However, a regain of the market is expected during 2021 even though the pandemic is still ongoing with the increasing demand for the e-commerce business being the driving force. Rising labour costs, strict emission norms, and growing demand for automation solutions are also mentioned as major growth drivers. Some of the biggest challenges of the material handling equipment market are the high

initial costs of the equipment, technical challenges and possible lack of awareness of the operating equipment. (Global Market Insights, 2021)

Based on a market research report by Fortune Business Insights (2021), in 2019 the global material handling equipment market size was around 212 billion USD, projected to reach 320 billion by 2027 with an average CAGR of 5.4% in the forecast period. As can be expected, there are slight differences between the estimated growth numbers depending on the source that is used. Figure 14 shows the market share of the different material handling equipment types. As can be seen, cranes and lifting equipment hold almost half of the total market share with growth expected to be moderate during the forecast period as well. The industrial truck sector is expected to grow significantly during the upcoming years due to e-commerce, ageing workforce and rising unit consignments. The continuous handling equipment sector includes for example conveyor systems, and it is expected to have moderate growth in the future due to industries like automotive, food and beverages, and pharmaceutical. Racking and storage equipment segment covers equipment like storage racks and automated storage and retrieval systems. This segment is expected to have consistent growth as a result of the increased need for storing bulk material and the growing use of automation solutions. (Fortune Business Insights, 2020)

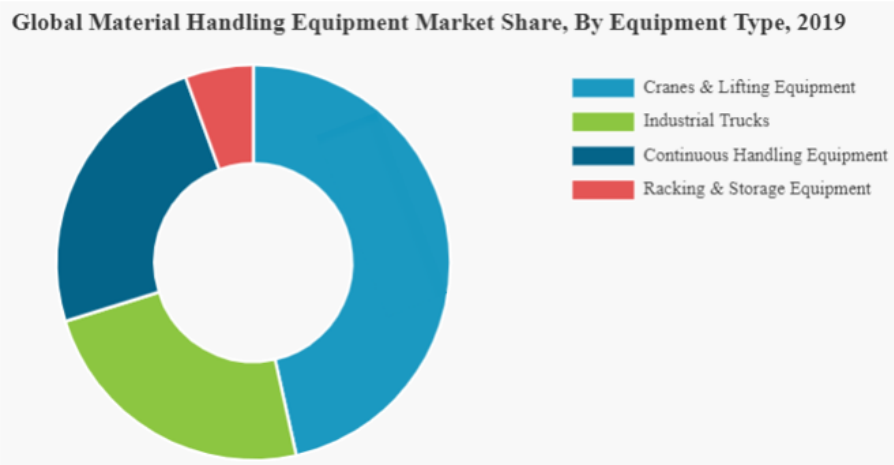


Figure 14. Market share of each equipment type (Fortune Business Insights, 2020).

When looking at the geographical segmentation of the market, the categorization is normally divided into North America, Latin America, Europe, Asia Pacific, the Middle East and Africa. Asia Pacific has held the largest market share and in the upcoming years it is expected to become an even more dominant market leader in the industry as the countries are in an increasing manner preferring the adoption of modern methods for material handling. According to Global Market Insights (2021), the Asia Pacific accounted for over 35% of the revenue share in the market in 2020. For North America the growth is anticipated to be substantial as the sales through e-commerce and the need for automated warehousing are increasing. In terms of Europe moderate growth is expected, although the needs are mostly the same as in North America. The Middle East and Africa should show consistent growth due to the big infrastructural investments and increased disposable income. On the other hand, in Latin America the market is anticipated to grow slowly as big players are focusing on expanding manufacturing facilities across several emerging countries. (Fortune Business Insights, 2020)

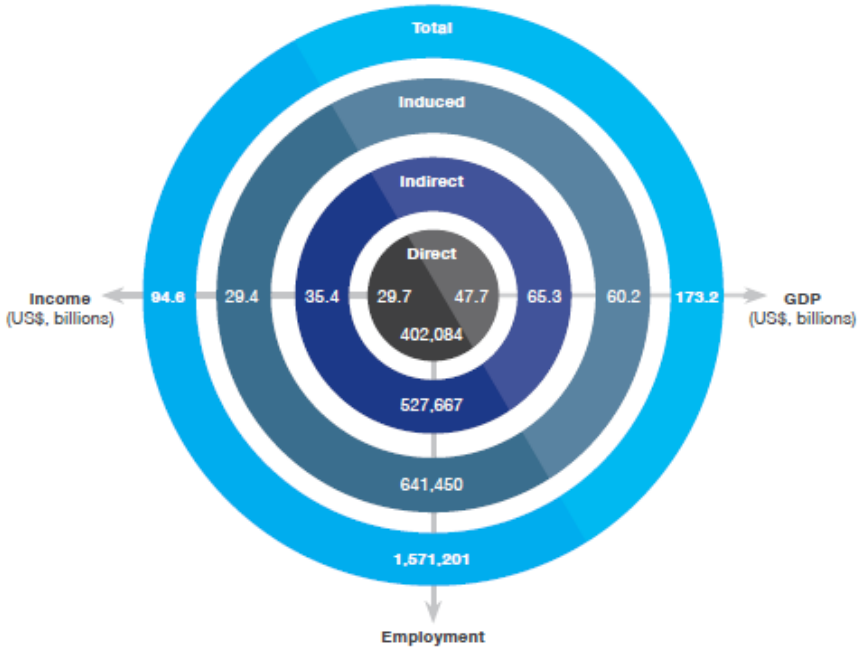


Figure 15. Material handling firms' economic impact in the US, 2018 (MHI, 2019).

In 2019 MHI and Oxford Economics released a report about the material handling industry in the US. Figure 15 shows the economic impact that the material handling companies had in the US in 2018. The material handling industry amounted a total of over 173.2 billion USD in GDP and 39.3 billion USD in taxes to governments. The size of the market is emphasized by the fact that in the US in 2018, material handling companies directly employed over 400,000 employees. Furthermore, for every worker in the industry an additional 2.9 jobs are supported in the wider economy through wage spending or supply chains. This means that with the total jobs multiplier of 3.9 the industry supported 1.6 million jobs in the US labour market in 2018. (MHI, 2019)

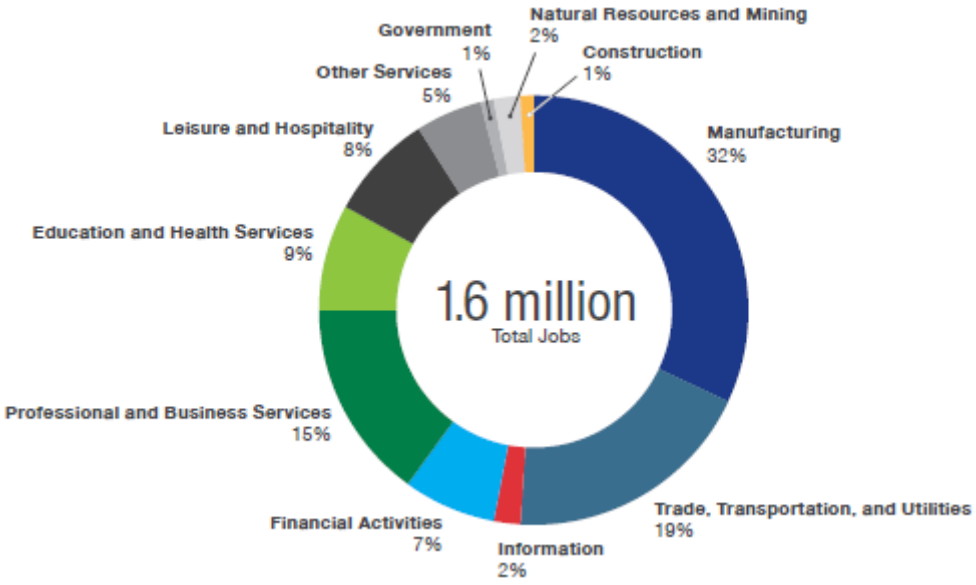


Figure 16. Share of sectors impacted by material handling jobs (MHI, 2019).

Figure 16 shows the impact that material handling jobs had on other sectors in the US in 2018. As can be expected, the manufacturing industry had the biggest employment impact accounting for 32% of the total impact. The following industries were trade, transport, and utilities with 19% share and professional and business services with 9% share. None of all the other sectors reached double-digit numbers. The impression of material handling industry having a diverse job creation for surrounding sectors is supported by the fact that non-manufacturing industries accounted for 68% of all jobs supported by the material handling industry. (MHI, 2019)

3 Methods

This thesis is conducted by combining qualitative and quantitative methods, although the research mainly contains a theoretical approach. Books, articles, industry reports and other academic sources are utilized to provide a review on the material handling equipment, technologies, market, and overall status of the industry.

Recording the financial figures of the companies working in the industry, with revenue, operating income and the number of personnel being the most important ones, make up for the majority of the thesis. Growth percentages of revenue and operating income are also introduced to help with determining who have been the best and worst performers in the industry. The financial figures are gathered through Suomen Asiakastieto Oy (2021), which is a reliable provider for company information and financials for Finnish companies. The study also includes an own section for the TOP20 material handling companies worldwide. The methods for choosing the companies for the study are described more thoroughly in the results section. The results are showcased in a table or figure form in the thesis to make the presentation simple. The original Excel sheet with all of the gathered data is given to the companies participating in the study for future purposes.

As a part of the study a questionnaire related to the development and outlook of the material handling industry in the 2020's was also conducted. The questionnaire was sent to a few Finnish material handling companies via email and the answers were gathered through telephone interviews. The presented questions are shown and analyzed in section 4.4. As mentioned earlier, two explorative remote workshop meetings were also held during the writing process together with the case companies and research participants to determine what is wanted from the study. Based on the suggestions, changes were made to the study scope.

4 Results

One of the main purposes of the study is to find out how the competition in the industry is looking like, which companies are working in the field and how they are doing based on their financial figures. This section provides an overall look into the industry by answering the above-mentioned questions. Close attention is also paid to the growth of the companies and to which companies have been performing well and which have not. Main products of the companies and customer references of some of the companies are also presented.

4.1 Companies and competition in the industry

The first part of the section focuses on the TOP20 material handling suppliers worldwide. The revenues of these companies and the location of their headquarters are showcased. Closer attention is paid to the Finnish companies in the industry. In the study, all the information about the companies, such as economic values and number of personnel were gathered into an Excel sheet from a 5-year period. The figures and tables presented in this section were created based on that information. In total, the study includes 97 Finnish material handling industry companies.

The data of the Finnish companies has been gathered through Suomen Asiakastieto website, which is a reliable information source for financials of the Finnish companies. All the information presented in the figures are based on the year 2019 or 2020. Suomen Asiakastieto only shows the information of the last 5 years for each company, which means that the research period had to be either 2015-2019 or 2016-2020. For most companies the values are from 2019 but for a minority, 2020 results were already available, and they were used to get the needed study period of five years. Few of the companies in the study have been founded relatively recently and, in these cases, the recorded values are taken from the years that are available. The amount of revenue is presented based on one decimal place, while operating income is based on three decimal places.

Only operating income growth percentages are discussed in this paper, which are based on the actual operating income results that were recorded into the Excel sheet.

All the Finnish companies have been manually searched for and chosen for the study, because the material handling industry cannot be specifically searched for in the industry search engines that are available online. This made the research process harder, and the chosen companies were hand-picked from general company listings. The websites of each of the companies were also browsed to find more information about their functions and products to ensure the suitability of choosing them for the study. The chosen companies were also later approved in a workshop meeting together with the study participants and case companies' representatives. Few of the companies that are considered to be part of the Suupohja region are not taken into account in the full listing of the Finnish companies as they only serve as a subcontractor company.

What should be noted is that the scope of the material handling industry is very broad, which together with the unavailability of a specific industry search makes it almost impossible to find each company working in the field. Each of the companies chosen for the study either manufactures or designs material handling solutions or acts as a consultation company. Companies that act solely as a retailer, subcontractor or in maintenance are excluded from the study to keep the scope reasonable. All areas of material handling are included in the company scope and the most common business areas and products are introduced later.

Although the growth percentage of operating income is not presented in the same figures together with the revenue, RPP and number of personnel, the operating income numbers will be presented for some of the companies in this section. The point of the gathered data is to provide a clear overlook on the companies' financial figures, which is why all the information is not put into the same figure. Section 4.3.2 will focus more on the companies that have been doing the best and worst based on growth in revenue and operating income. The studied companies have been divided into five separate ranges

based on their latest revenue to keep the presented information clear. These ranges are >50MEUR, 10-50MEUR, 2-10MEUR, 1-2MEUR and <1MEUR.

Table 1. Example table representing the way in which the information was gathered for each Finnish company.

Company	Revenue MEUR	Operating income MEUR	Number of personnel	Year	Municipality	Products
Cargotec Finland	1208.9	37.422	753	2019	Helsinki	cargo handling machines
	1079.5	36.012	656	2018		
	1085.9	3.286	658	2017		
	1131.3	16.757	601	2016		
	1158.2	15.646	567	2015		
Konecranes Finland	782.7	75.3	1546	2019	Hyvinkää	cranes, transportation machines
	673.5	82.3	1472	2018		
	608.1	36.4	1457	2017		
	680.1	50.9	1513	2016		
	593.1	27.6	1554	2015		
Mitsubishi Logisnext Europe Oy	158.5	5.108	442	2020	Järvenpää	forklifts, automation solutions
	145.3	-7.34	423	2019		
	124.1	-14.802	398	2018		
	113.9	-0.74	369	2017		
	89.2	-0.08	289	2016		

4.2 Worldwide companies

The TOP20 material handling system suppliers worldwide based on revenue are showcased in Figures 17 and 18. The information is based on 2019, which means that the effects of the COVID-19 pandemic are not yet evident. Modern Materials Handling provides an updated list of the top suppliers each year. The TOP20 list remained, for the most part, in the same order as in earlier years and on average the revenues in 2019 grew 7.3 percent with the total revenue of the companies being 23 billion USD. Biggest reason for the growth was the increased demand in automation and several businesses investing more into automation projects to cope with the needs of e-commerce. (Bond, 2020)

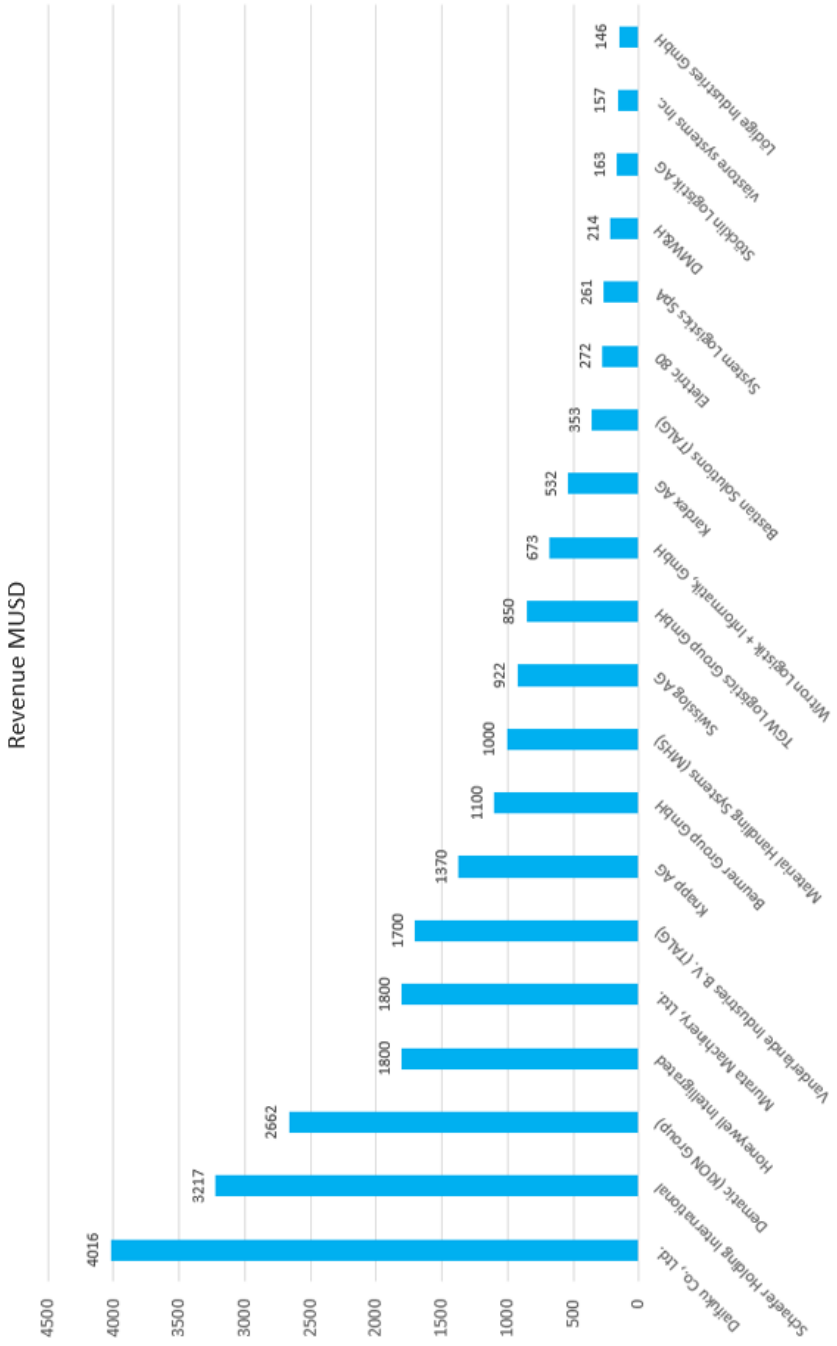


Figure 17. Revenue of TOP20 material handling companies worldwide.

The criteria for the companies to qualify for the list was strict and clearly specified. One criterion was that the companies had to have business in North America and have the capability of reporting the revenue they get directly from contracts related to material handling. The chosen companies also had to be suppliers of actual material handling systems, not only providers of certain equipment. Each of the companies had to have

full-time personnel who manufacture and design a minimum of two different material handling systems such as transportation vehicles, data collection and management systems, picking systems, storage equipment or other sorts of material handling equipment. (Bond, 2020)

In total, 10 of the 20 companies on the list experienced double-digit percentage growth in 2019. The three companies with the biggest positive change in revenue were Murata Machinery (34.1%), Knapp (30.5%) and Material Handling Systems (16.3%). The three worst performing companies based on revenue in 2019 were Lödige Industries (-22.3%), Viastore SYSTEMS (-20.3%) and Daifuku (-3.6%). The companies in the list remained entirely the same as in the 2018 list, with only a few places being swapped between companies. The top 4 companies were also still in the same order, although Murata Machinery climbed to tie for 4th place, due to their 34.1% growth in 2019. (Bond, 2020)

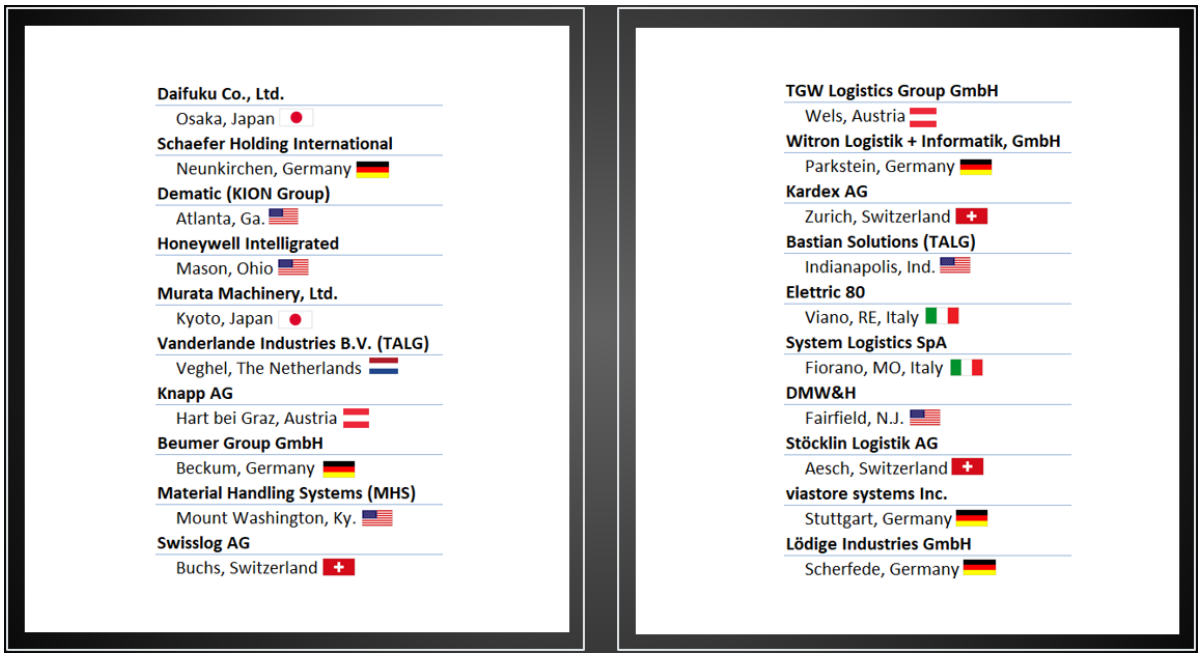


Figure 18. Location of the headquarters of TOP20 material handling companies worldwide.

4.3 Finnish companies

4.3.1 Revenue, RPP and number of personnel in each company

This section showcases the revenue, RPP and number of personnel for each of the 97 Finnish companies that have been chosen to be part of the study. The information is presented in several different figures for the sake of clarity with the companies being put in order from largest to smallest revenue from latest year. In each range the best and worst performers in terms of operating income are also mentioned, although in section 4.3.2 these will be discussed in the extent of the whole study.

As mentioned earlier, the information of each company is gathered from Asiakastieto.fi. What should also be noted is that the presented values are specifically from the companies' Finnish functions. For example, in the case of Cargotec and Konecranes, both have activity all over the world but only the values of their Finnish functions have been considered to get a better understanding of the industry specifically in Finland.

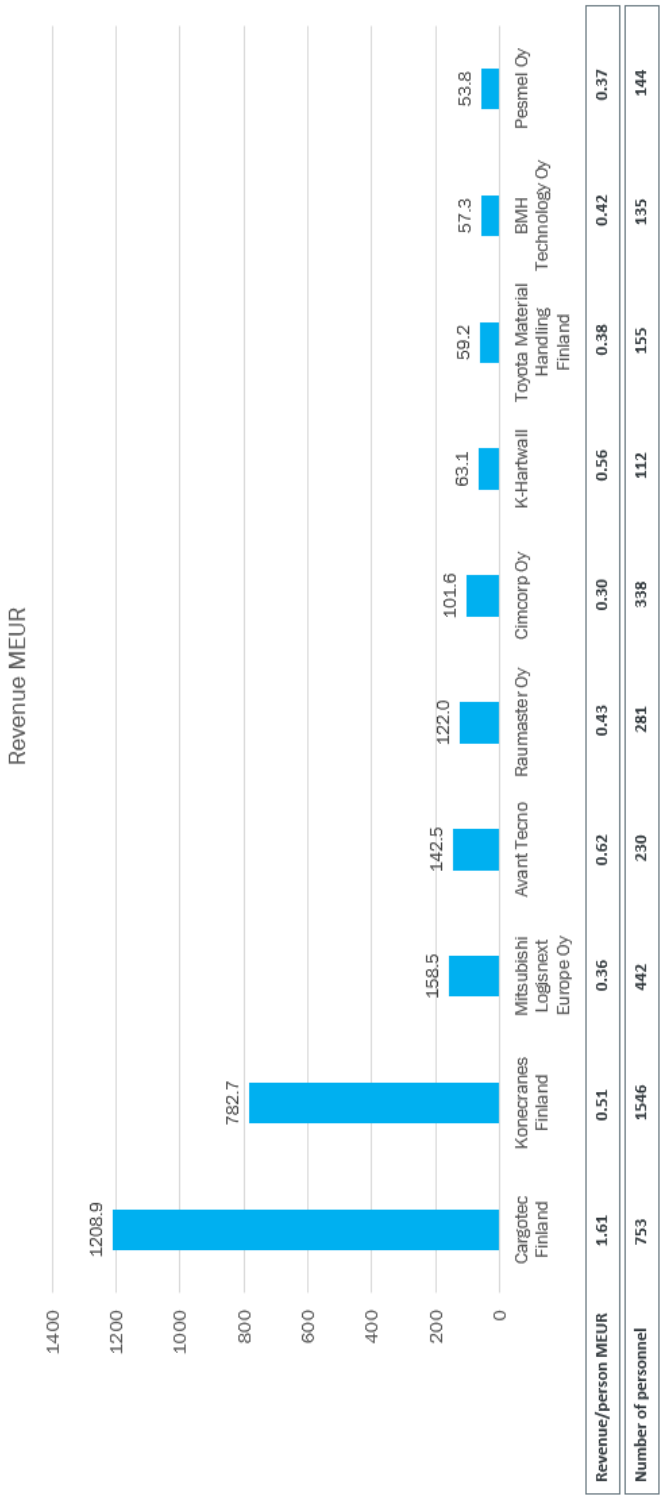


Figure 19. Finnish material handling companies with over 50MEUR revenue.

As can be seen from Figure 19, there are in total ten Finnish material handling companies with over 50MEUR yearly revenue. Cargotec and Konecranes are clearly the biggest

players in the industry and could compete even against the worldwide competition that was presented earlier. All the other companies have a revenue of under 160MEUR with Pesmel being to last one to make the list with 53.8MEUR revenue. There does not seem to be a clear favorite in terms of product range in the TOP10 companies. The products include, for example, cranes, forklifts, loaders, conveyors, packing lines, robotics, and automation systems.

Both Cargotec and Konecranes have similar product ranges with both operating in the cargo handling and crane business. What should be mentioned is that on the 1st of October 2020 it was announced that Cargotec and Konecranes will merge and form a global leader in the material flow industry. The annual sales of the illustrative future company were about 7 billion EUR and operating income around 565 million EUR in 2019. Altogether, as of June 2020, these two companies had a total workforce of approximately 29 400 employees in over 50 countries. The expected completion date for the merger is in the fourth quarter of 2021 and as a result of the merger Konecranes will dissolve. The name of the future company is to be determined. (Cargotec, 2020)

The main purpose of the merger is to create a leading company in the field of sustainable material handling by focusing on safety, productiveness, decarbonization and effectiveness. The aim of the merger is to strengthen the business positions of the future company in various industries and to be beneficial from the standpoints of customers, employees, shareholders and product or service offering. The future company will focus on both companies' expertise in the best possible way to ensure the benefits of all stakeholders. The extra value for shareholders will be created, for example, by attracting global talents, expanding the R&D scope and focusing on the cost synergies to make sure that the results have a value higher than the sum of their parts. (Cargotec, 2020)

The TOP10 companies have been performing effectively in the 5-year period with the average increase in revenue being 42.8%. The companies with the biggest growth were Cimcorp (84.4%), Mitsubishi Logisnext Europe (77.7%) and Avant Tecno (61.6%). The

smallest revenue growth in the period was for Cargotec (4.4%) and BMH Technology (5.5%). All the other companies had double-digit growth in the 5-year period. Based on the growth percentage of operating income, the companies that have been doing the best are Mitsubishi Logisnext Europe (6485%), Pesmel (180.3%) and Konecranes (172.7%). The worst operating income trajectory in the 5-year period was for K-Hartwall (-68.3%) and Cimcorp (-66.5%). Each of the other companies had double-digit growth in operating income.

When looking at the development of operating income of the companies, it is important to remember that there are various actions and decisions happening within the companies that are not always available for the public or might be announced with a delay. Based on the information found in the study it can be concluded that the operating income returns vary greatly between each year and are often not related to the amount of revenue the company has been able to generate. Big investments, business rearrangements and company buyouts or acquisitions can have a big effect on the operating income for several years, as it can take a long time until new investments to the business start creating value and returns for the company. Therefore, the growth of operating income is not always the best indicator of how a company is actually doing.

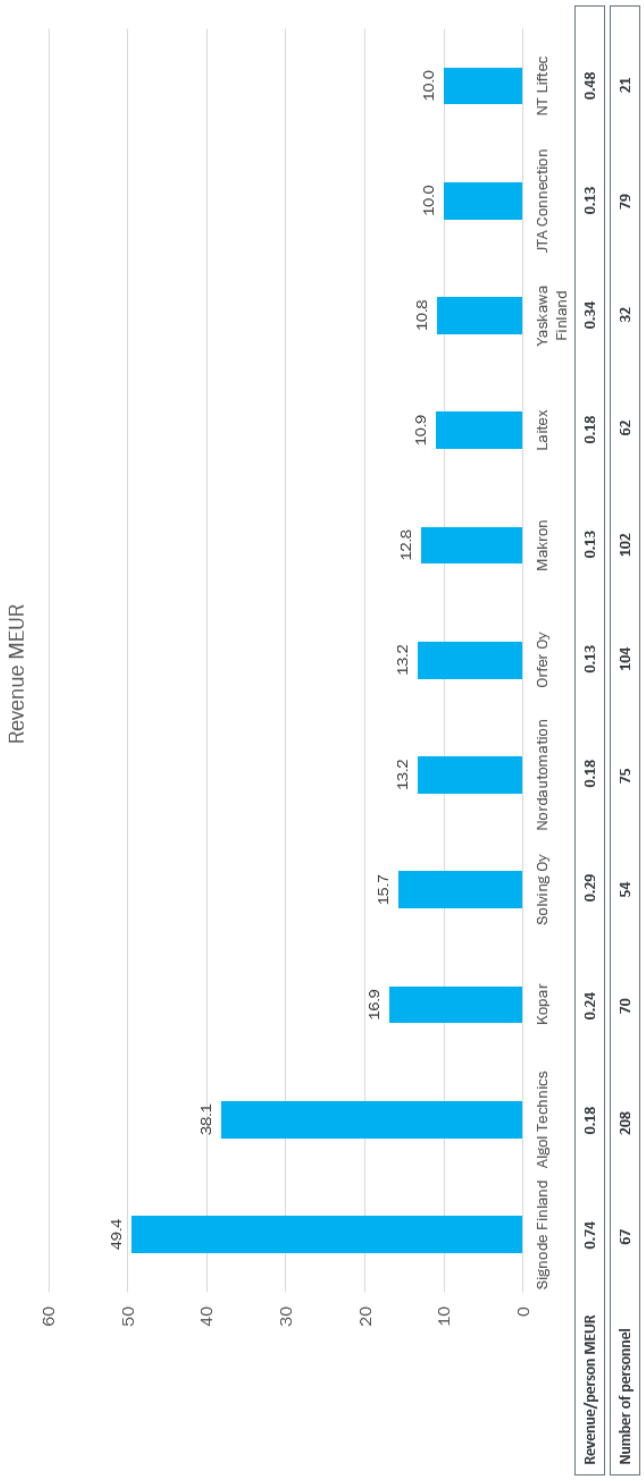


Figure 20. Finnish material handling companies with 10-50MEUR revenue.

Figure 20 showcases the next wave of companies based on the revenue, this time in the range of 10-50MEUR. In this scope, there are once again two companies that clearly have the biggest amount of revenue. These companies are Signode and Algol Technics, with

the remaining companies all having below 17MEUR revenue. The biggest growth in revenue, however, has been achieved by Yaskawa (61.2%), Orfer (37.5%) and Laitex (22.5%). Only companies with a negative growth in revenue were NT Liftec (-12.3%) and JTA Connection (-4.8%). However, JTA Connection is a relatively new company for which only the information from 2018 and 2019 were available.

Operating income has been growing the fastest for Yaskawa (244.8%), Kopar (188.3%) and NT Liftec (101.6%). Surprisingly, five of the eleven companies had a negative operating income growth in the period with Makron (-276.6%), Orfer (-84.8%) and Nordautomation (-82.4%) being the ones with the biggest decrease. In this case, Orfer simultaneously had one of the biggest growths in revenue and also the biggest decrease in operating income, which is a great example of how the growth in revenue and operating income do not always go hand in hand. With the amount of companies being so large in the study, the reasoning behind some companies having such decreases in operating income while having great growth in revenue has not been investigated further.

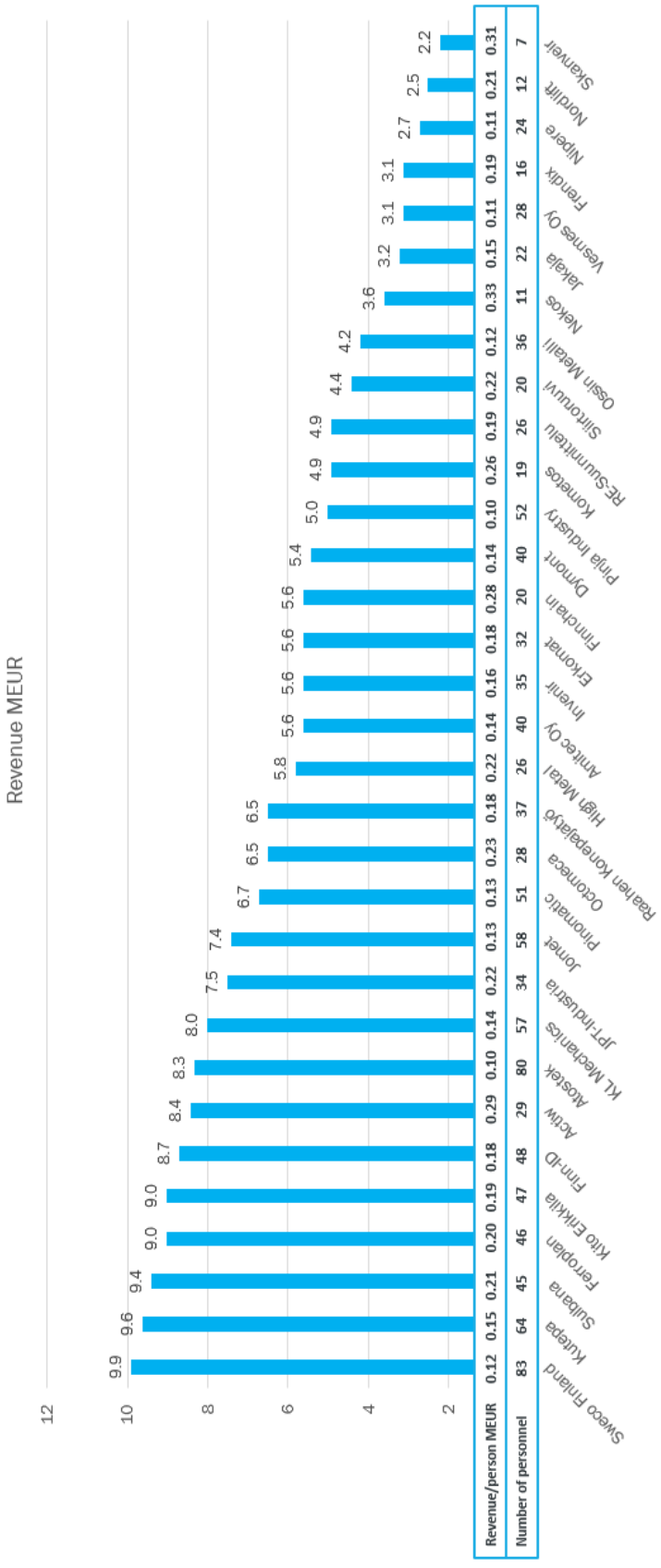


Figure 21. Finnish material handling companies with 2-10MEUR revenue.

In the range of 2-10MEUR yearly revenue (Figure 21) the competition gets much tighter. There are no clear standout companies, and the spread is even all the way from top to bottom. The number of personnel for each of the companies is below 100 and the RPP is spread in the small range of 0.10-0.33MEUR. Companies from different fields of material handling are also well presented, although in this range most companies manufacture either conveyor or production line solutions.

The growth in revenue has been the biggest for Dymont (200%), Skanveir (144.4%) and Invenir (143.5%). Only three of the 32 companies have had negative growth, of which Amitec (-66.3%) had clearly the biggest decrease. Nipere (-15.6%) and Nordlift (-10.7%) were the other negative performers, although for these two companies the information was only available for two separate years. In terms of operating income growth, the best performers have been Jakaja (23500%), RE-Suunnittelu (1630.8%) and Frendix (970.6%), whereas Jomet (-2085.5%), Amitec (-1417.2%) and Kito Erikkila (-456.1%) have had the biggest decrease. Erikkila joined the KITO Group in 2018 and the following year their operating income declined by a lot, which could be explained by the arrangements that had to be made in the process. (KITO Erikkila, 2021)

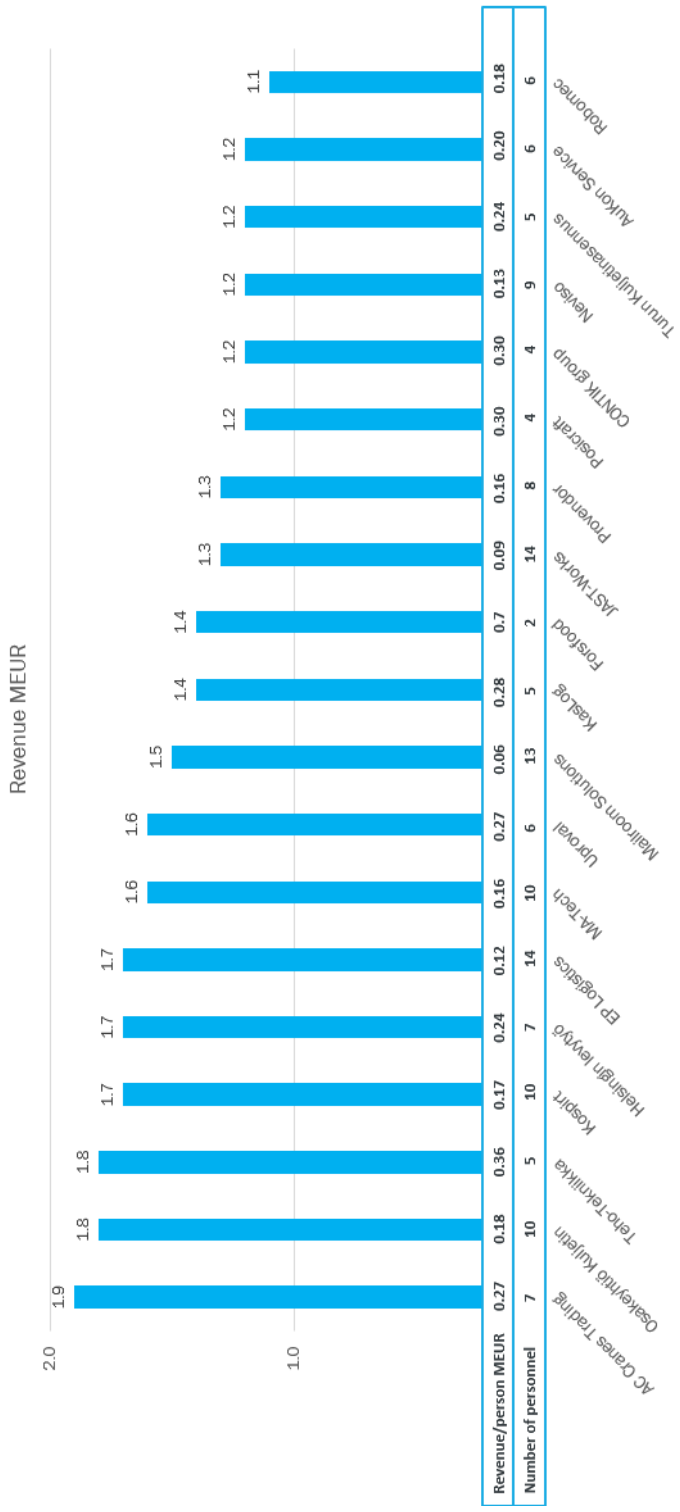


Figure 22. Finnish material handling companies with 1-2MEUR revenue.

The range of 1-2MEUR revenue is shown in Figure 22. Here the competition is tight once again and each decimal point is presented. Best performers in terms of revenue growth

in the 5-year period have been CONTIK Group (300%), Posicraft (300%) and JAST Works (116.7%). Worst performers, on the other hand, have been companies like Robomec (-21.4%), KasLog (-17.6%) and EP Logistics (0%). As can be seen from the results, this range has been performing very well in general and even the results of the worst performing companies are not negative by much. Based on operating income, growth has been the biggest for Osakeyhtiö Kuljetin (2950%), CONTIK Group (1171.4%) and AC Cranes Trading (1163.6%). Worst performers have been Mailroom Solutions (-533.7%), KasLog (-140.2%) and EP Logistics (-52.6%).

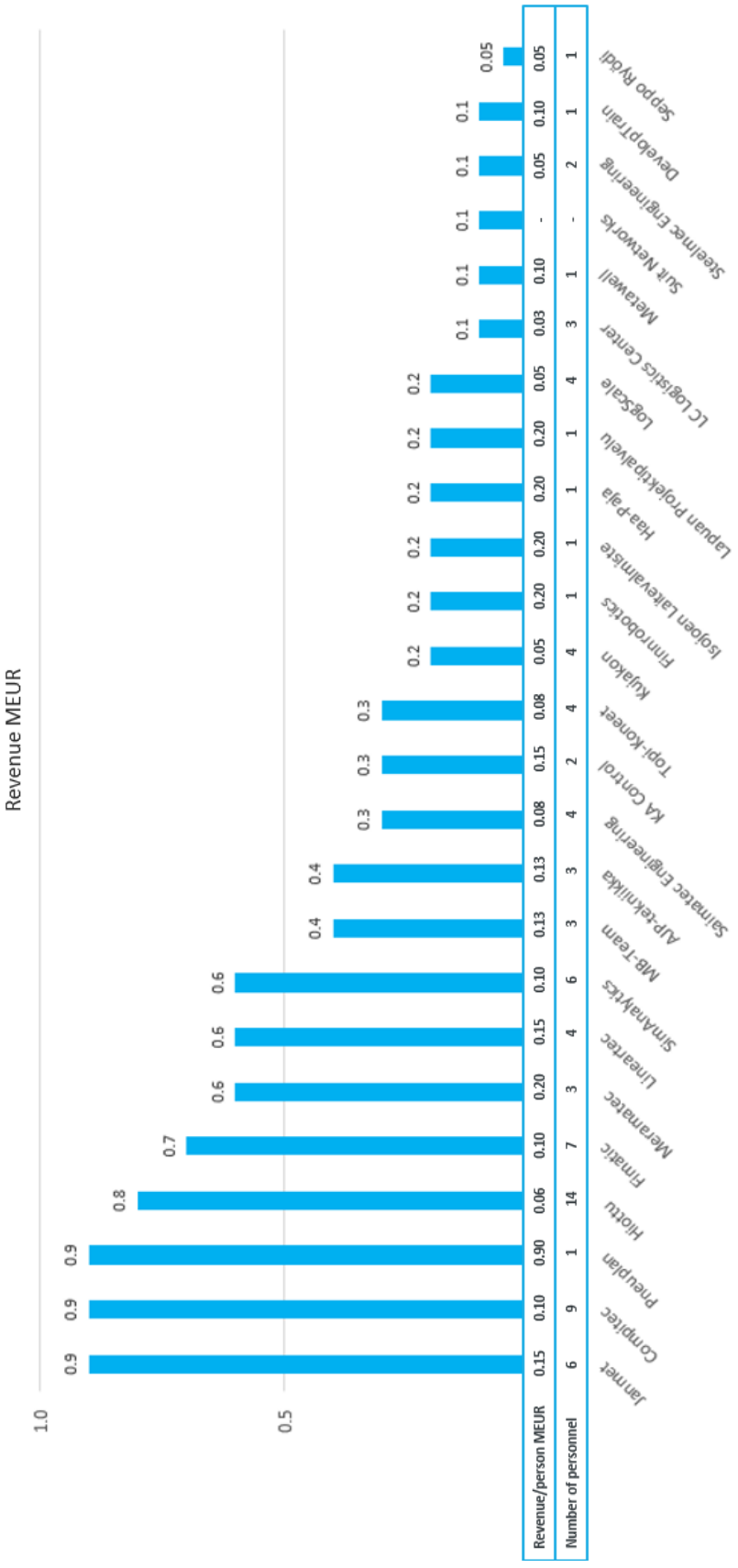


Figure 23. Finnish material handling companies with 0-1MEUR revenue.

The smallest material handling companies based on revenue are presented in Figure 23. Here the revenue of each company is below 1MEUR and the majority of the companies are located in the bottom end of the scope. The number of personnel in the companies is below ten, except for Hiottu, which has 14 employees in total. In this range about one third of the companies are led by self-employed entrepreneurs, who might also have daytime jobs at another company. This in itself explains the small revenue amounts and RPP. Overall, it can be said that these companies do not play a big part in the Finnish material handling industry as their market share is so small.

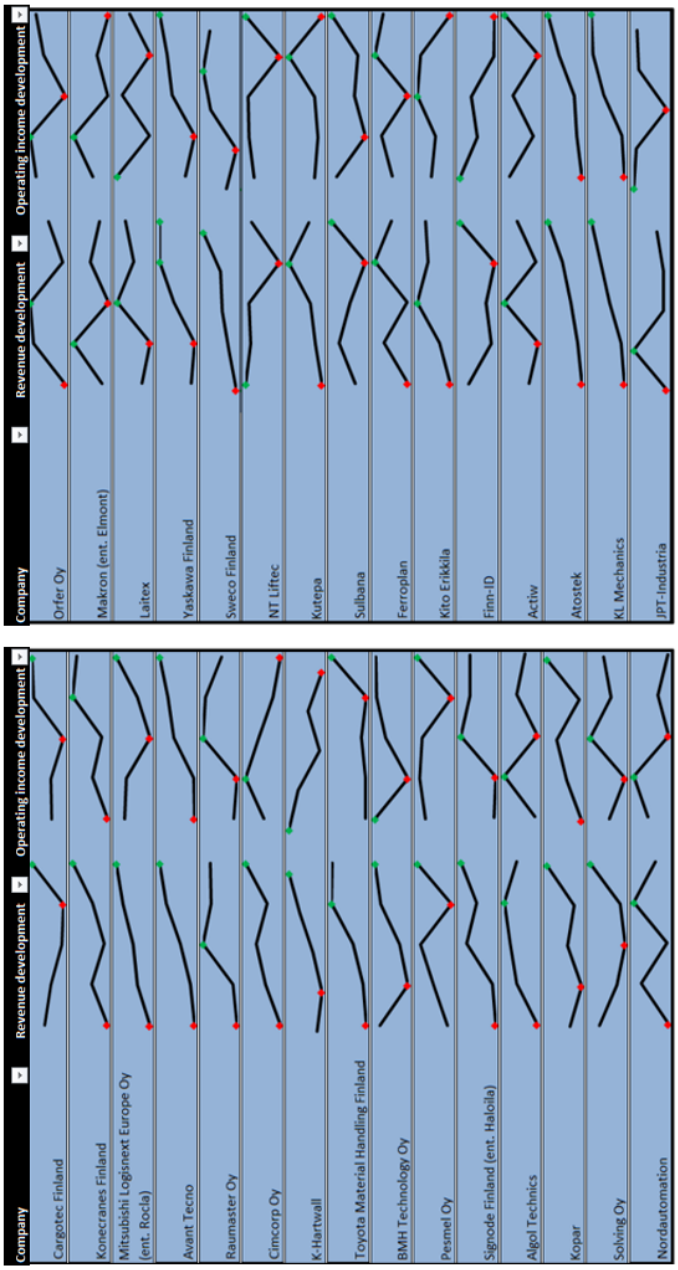
Biggest growth in revenue has been for Hiottu, SimAnalytics, MB-Team, Isojoen Laitevalmiste and Lapuan Projektipalvelu, who all had 100% growth in the study period. The worst performers based on revenue have been Saimatec Engineering (-93.5%), Finnrobotics (-83.3%) and Kujakon (-60%). What is worth mentioning is that as the revenues are rounded to one decimal, the percentage amounts can be imprecise in the companies with the smallest revenues. This starts to show especially in this smallest range as many of the companies only have 0.1-0.3MEUR revenue and even a small change in revenue can have a big effect on the percentage. In terms of operating income, the top performers have been Lapuan Projektipalvelu (540%), LC Logistics Center (180%) and Janmet (133.3%). Lowest percentages have been for Compitec (-380%), Topi-Koneet (-108.3%) and Suit Networks (-97.8%). Although the percentages seem to be quite high for the best and worst performers, it needs to be remembered when talking about these smallest companies in the industry, that the changes can be big even though the operating income has not changed by too much in terms of euros.

4.3.2 Companies with the best and worst success

This section focuses on finding out which companies have been doing the best and worst based on the growth numbers and trajectory of revenue and operating income. Each individual company is not investigated closely, as the attention is paid to the TOP30 companies based on revenue (Table 2) and the companies with highest and lowest growth

percentages and the amount of change in the study period (Tables 3 and 4). The idea is to get a better general idea about the performance and competitiveness of the studied companies.

Table 2. Development of revenue and operating income in TOP30 companies based on revenue.



The sparklines in Table 2 represent the development of revenue and operating income in the 5-year period that was chosen for the study. The red dots indicate the point where

the revenue or operating income of the company has been at the lowest, and the green dots show when they have been at the all-time high value. No actual number values are shown in this table, as the point is just to give an idea about how the biggest Finnish companies in the industry have been developing.

Majority of the companies have experienced growth in revenue over the 5-year period with the only exception being NT Liftec, whose revenue has decreased from 11.4MEUR in 2016 to 10MEUR in 2020. The growth in revenue has been the steadiest for companies such as Mitsubishi Logisnext Europe, Avant Tecno, Atostek and KL Mechanics, who have grown their revenue evenly over the years. K-Hartwall, Yaskawa and Sweco also deserve a mention for their impressive growth. For 17 of the 30 companies, the latest year has been the best in terms of revenue, which can be seen from the number of green dots on the right-hand side of the revenue development column.

In terms of operating income, the results vary more between companies each year. There is no clear correlation that steady growth in revenue automatically results in steady growth of operating income as well, which has to do with the factors that were mentioned earlier, such as company investments. 12 of the 30 companies had their highest operating income in the latest presented year, which means that five companies were not able to increase their operating income although they had their best year in terms of revenue.

Table 3. Companies with the biggest growth in revenue and operating income.

Company	Revenue growth% 2015/2016 – 2019/2020	Change MEUR
Posicraft	300%	0.3 → 1.2
CONTIK Group	300%	0.3 → 1.2
Dymont	200%	1.8 → 5.4
Atostek	151.5%	3.3 → 8.3
Skanveir	144.4%	0.9 → 2.2
Invenir	143.5%	2.3 → 5.6
AuKon Service	140%	0.5 → 1.2
Nekos	125%	1.6 → 3.6
JAST-Works	116.7%	0.6 → 1.3
Mailroom Solutions	114.3%	0.7 → 1.4
Forsfood	100%	0.7 → 1.4

Company	Operating income growth% 2015/2016 – 2019/2020	Change MEUR
Jakaja	23500%	-0.002 → 0.468
Mitsubishi Logisnext Europe	6485%	-0.08 → 5.108
Osakeyhtiö Kuljetin	2950%	-0.002 → 0.057
RE-Suunnittelu	1630.8%	0.026 → 0.45
CONTIK Group	1171.4%	-0.007 → 0.075
AC Cranes Trading	1163.6%	0.022 → 0.278
Frendix	970.6%	0.034 → 0.364
Invenir	915.4%	0.078 → 0.792
Posicraft	616.7%	-0.018 → 0.093
Skanveir	579.5%	-0.083 → 0.398
Sweco Finland	577.8%	0.036 → 0.244

Table 3 shows the companies that have performed the best in terms of growth in revenue and operating income in the five-year study period. The biggest growth in revenue has been for Posicraft (300%), CONTIK Group (300%) and Dymont (200%). All of the companies to make the list are relatively small with most ranging in the 1-6MEUR revenue area. The operating income section offers some astonishing numbers with Jakaja (23500%), Mitsubishi Logisnext Europe (6485%) and Osakeyhtiö Kuljetin (2950%). However, here most of the companies are also quite small and even a slight change in operating income has a big effect on the growth percentage. A great example of this is Osakeyhtiö Kuljetin, whose result has changed from -2000 EUR to 57 000 EUR. This leads to a high growth rate, but the actual money amounts are still very small.

Table 4. Companies with the smallest growth in revenue and operating income.

Company	Revenue growth% 2015/2016 – 2019/2020	Change MEUR
Saimatec Engineering	-93.5%	4.6 → 0.3
Finnrobotics	-83.3%	1.2 → 0.2
Amitec	-66.3%	16.6 → 5.6
Kujakon	-60%	0.5 → 0.2
Topi-Koneet	-40%	0.5 → 0.3
AJP-tekniikka	-33.3%	0.6 → 0.4
Robomec	-21.4%	1.4 → 1.1
KasLog	-17.6%	1.7 → 1.4
Nipere	-15.6%	3.2 → 2.7
Meramatec	-14.3%	0.7 → 0.6
NT Liftec	-12.3%	11.4 → 10

Company	Operating income growth% 2015/2016 – 2019/2020	Change MEUR
Jomet	-2085.5%	0.055 → -1.092
Amitec	-1417.2%	0.029 → -0.382
Mailroom Solutions	-533.7%	-0.104 → -0.659
Kito Erikkilä	-456.1%	0.214 → -0.762
Compitec	-380%	0.005 → -0.014
Makron	-276.6%	0.269 → -0.475
KasLog	-140.2%	0.328 → -0.132
Topi-Koneet	-108.3%	0.012 → -0.001
Suit Networks	-97.8%	0.045 → 0.001
Finn-ID	-94.8%	0.421 → 0.022
Seppo Ryödi	-90%	0.010 → 0.001

Table 4 focuses on the worst performing companies based on revenue and operating income growth percentage. Although all of the values are negative, the percentages are much more moderate when compared to the best performers presented in Table 3. The fall in revenue was the biggest for Saimatec Engineering (-93.5%), Finnrobotics (-83.3%) and Amitec (-66.3%). Amitec has also had the biggest drop in monetary value with revenue dropping from 16.6MEUR to 5.6MEUR.

Some of the decreases can be explained by the companies letting go of some of their business operations or investing more into product development and research. For example, Saimatec Engineering moved their key business area of roll handling and roll wrapping systems under the company named Uproval, which is one of the biggest reasons for their decrease. (Uproval, 2021) Uproval is also included in the study as an individual company.

4.3.3 Products and customers of the companies

This section presents the main products that the Finnish material handling companies manufacture or offer in general (Figure 24), the material types that are transported with

these products (Figure 25) and the customer references of some of the material handling companies (Figure 26).

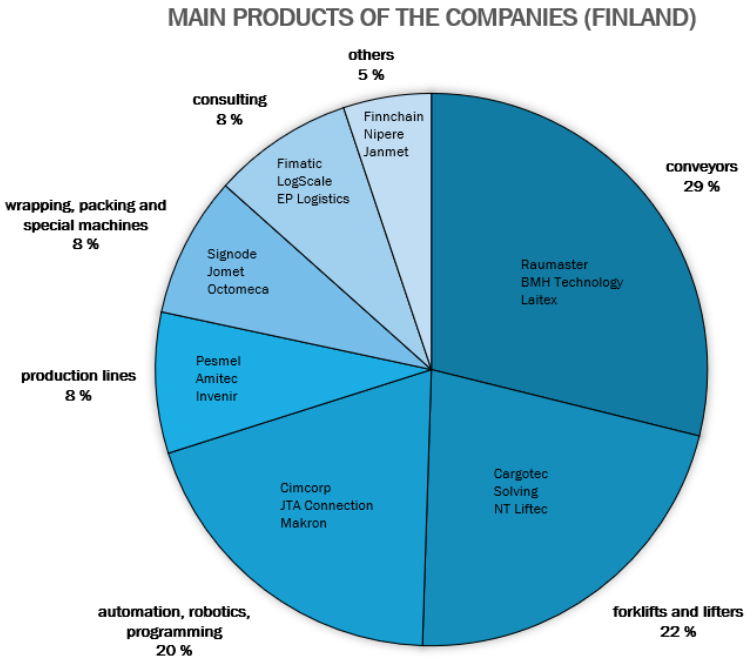


Figure 24. Main products of the Finnish material handling companies.

The material handling products of the companies have been divided into seven individual categories to keep the presentation layout simple. The precise content and product scope of each sector is described as well. Three example companies who manufacture or offer those exact products or solutions are showcased in each part of the pie chart. The size or the amount of revenue of the companies are not considered here, which means that each company is on the same line and the most suitable category has been chosen for every company. What made the task harder was that the majority of the 97 companies provide various solutions to the material handling industry, which made it challenging to decide which company to put into which category. In these cases, closer attention was paid to the websites of the companies to find out what are their main products and most common solutions.

There are three clearly biggest product sections in the material handling industry in Finland, which are:

- Conveyors (29%)
- Forklifts and lifters (22%)
- Automation, robotics, and programming (20%)

The conveyor section also includes products such as elevators, pumps, crushers, and general material handling systems. Conveyors are used to move mainly bulk material, which is transported in large quantities and has a small grain size. They are manufactured by companies such as Raumaster, BMH Technology and Laitex. The forklift and lifter section includes all the solutions that are used to transport countable material that is not transported via conveyors or production lines. This includes, in addition to all sorts of forklifts and lifters, solutions such as AGVs, air film movers, air bearing modules, lifting jacks, loading bridges, cassette systems and vacuum grippers. Companies manufacturing forklifts and lifters are, for example, Cargotec, Solving and NT Liftec.

Cimcorp, JTA Connection and Makron are companies that focus on automation, robotics, or programming solutions, which is another big sector in the industry. In the study this sector includes all companies, whose main products are solutions related to automation systems, software and programming, computer vision, digitalization, cloud services and robots. Next up is the production line sector with 8% share of the total market. The production line manufacturers have their own sector in the pie, although many of these bigger production line solutions can also include products from the conveyor sector and it is hard to draw the line in which sector to include each company. The sector includes companies like Pesmel, Amitec and Invenir, who manufacture production lines, packing lines and other factory lines based on the customer's needs. All in all, these solutions are normally bigger entities than the ones manufactured by the conveyor sector companies.

Wrapping, packing and special machines present an 8% share of the total equipment market in Finland. The overall product scope of the sector also includes strapping machines, stretch wrapping machines, stretch hooding machines, sacking machines, and cutting machines. These are manufactured by companies such as Signode, Jomet and Octomeca. Consulting sector also covers 8% of the total market, and it is represented by companies like Fimatic, LogScale and EP Logistics. These companies serve their customers in the planning and implementation phases of system deliveries related to logistics and production organizations. They can also work in an expert role for supplier companies on demanding customer projects and consult companies on the compliance of their supply chains. Services range from the development of logistics strategies to practical solution implementations. The last sector is the sector that contains all the products which cannot be appointed to any other sector, which is 5% of the total pie. This includes companies like Finnchain, who manufacture sludge and chain scraper systems and Nipere, who manufactures mill and feed mixing systems under Rivakka brand.

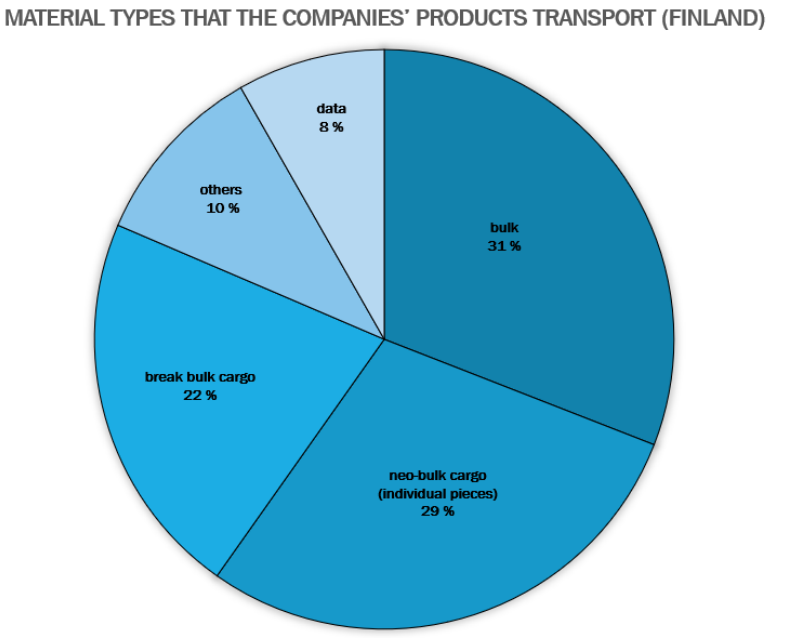


Figure 25. Material types that are transported with the companies' products.

The share of different material types that are transported with the products of the companies are shown in Figure 25. Each company has been categorized based on their

products and the material that is transported with them. Each company is on the same line in the classification and size of the company has no effect. Bulk-material is clearly the biggest sector with a 31% share, and it includes all materials that have a small grain size, such as powders and woodchips, that are transported generally via conveyors. Neo-bulk cargo covers 29% of the pie chart overall and it includes all loose piece materials that are transported via lifters, forklifts, and robots, or with the help of wafters, roller cages and containers. Break bulk cargo takes up 22% of the total and includes all countable material that is transported via production lines or conveyors and has a bigger grain size. The last sector is categorized as the “Others” sector, and it covers 10% of the total share and includes mainly the consultation companies, who do not really have physical materials that are transported, as they only provide their expertise to the customers. The last material category is data, which covers 8% of the pie chart. This includes companies who offer solutions related to data storage, cloud services, digitalization, and programming.

Figure 26. Customer references of Finnish material handling companies.

The customer references for ten Finnish material handling companies are presented in Figure 26. The companies were chosen based on the fact that they had to have the customer references available for the public, which is not the case for most of the

companies. The majority of the companies do not want to publicly announce who their customers are and choose to, for example, only present the different solutions they have delivered without mentioning the specific customer. This most likely has to do with the fact that by finding out the customer, competing companies could contact them and offer their own solutions instead. The references have been gathered from the official website of each company and the idea is to provide a good insight on the nature of the companies that order material handling solutions and in what fields of business or industry these companies function in.

Overall, there are several fields of industry that stand out as the most common ones for the customers of material handling products. The biggest of these seems to be the food and beverage industry, which includes companies like Valio, Saarioinen, HK, Kinnusen Mylly, Paulig, Arla, Olvi, Fazer, Orkla, Vaasan, NordicSoya, Raisio, Nestle, Dansukker and Brunberg, who are all presented in Figure 26. Most of the products delivered to this field of industry are manufactured by companies who manufacture conveyors and production line systems, such as Orfer, Amitec and Jakaja. This is to be expected as this type of solutions can be used to transport large quantities of material effectively within a factory, which is essential in the food and beverage industry.

The metal, mining, wood, and paper industry companies are also well presented in the customer references. The companies that are a part of these industries are Metsä Group, Kontino, SSAB, Metso, Södra, Stora Enso, Sandvik, SMA Mineral, Lunawood and Raute. For these industries the most common solutions have been the conveyor and production line deliveries by companies such as Kospirt and Raumaster, who are specialized in manufacturing solutions for transporting bulk material. Software, machine vision, and cloud service solutions have also been popular with Atostek and Hiottu delivering their solutions to companies like Sandvik, SSAB, Raute, Lunawood.

The transportation vehicle industry is also well represented by companies like VR, CAT, Volvo, Valmet Automotive, MAN and Finnair acting as the customers. For this industry

the delivered solutions have been mainly automated storaging, AGV, air film mover and packing line solutions by Algol Technics and Solving. Another popular industry is the healthcare industry, which includes companies such as Fimlab, HUS, OYS, Orion and Nexstim. The variety of solutions delivered to the healthcare industry have been wide, with Algol Technics, Amitec, Atostek and Finn-ID all acting as the suppliers. Especially the digitalization and logistic ERP systems by Finn-ID have been popular with them supplying both Fimlab and HUS. The agriculture industry is also well featured by companies like Hankkija, Lantmännen Agro, Viljava and Biolan, who all are customers of Jakaja, who manufactures conveyors, elevators, and pipe systems for transporting bulk material.

4.3.4 Summary

This section aims to summarize the development of the Finnish material handling companies in general, without focusing on individual companies. It will look at factors such as the total development of total revenue and operating income, average growth percentages for both of them and the total amount of personnel working in the industry. The average growth percentages have been calculated by taking the average value of all of the companies from the 5-year period. The amount of revenue or the general size of the company has no effect as in this case each company has equal weight.

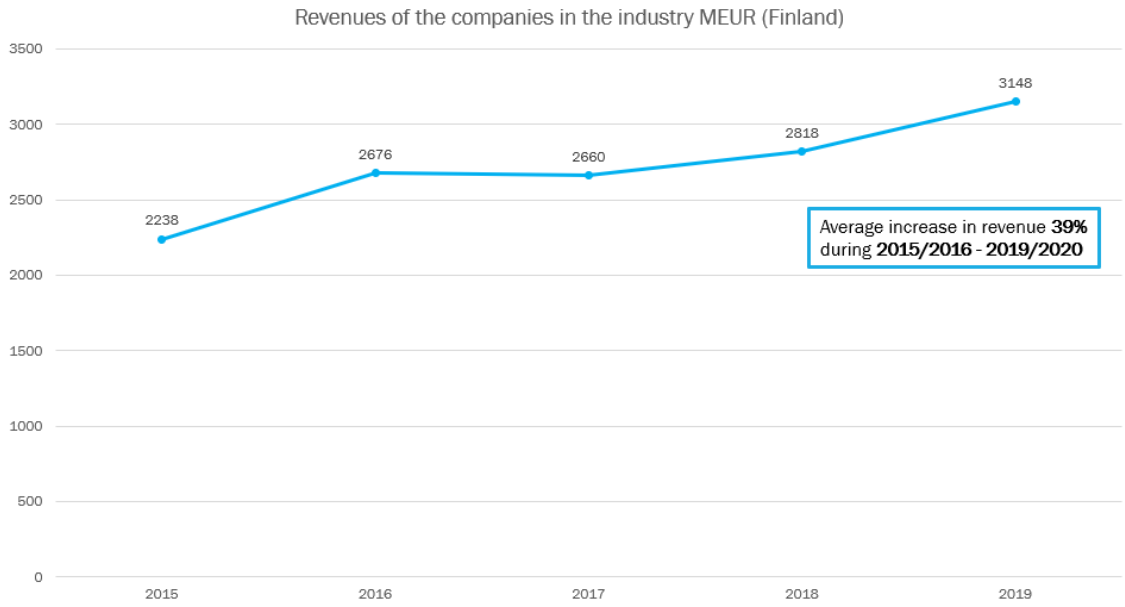


Figure 27. Total revenues of the companies during 2015-2019.

Figure 27 presents the total revenue of all of the 97 companies combined in the 5-year period of 2015-2019. The trajectory of the revenues has been going upwards steadily, although between 2016-2017 the total amount decreased very slightly. Average increase in revenue during the timeline has been 39%. Based on the results, it can be said that the industry is constantly growing in Finland and the need for material handling solutions is not slowing down. What should be remembered is that the two biggest companies accumulate almost two thirds of the total revenue amount with Cargotec having 1208.9MEUR and Konecranes 782.7MEUR revenue. Once the merger that was discussed in section 4.3.1 officially goes through, the future company will have majority of the market share in Finland.

Table 5. Summary of average revenue increase in percentage.

	>50MEUR revenue	10-50MEUR revenue	2-10MEUR revenue	1-2MEUR revenue	<1MEUR revenue
Average percentage increase in revenue (in 5 years)	42.8	16.9	46.4	74.2	14.4
in a year	8.6	3.4	9.3	14.8	2.9

The average percentage increase in revenue for each of the earlier shown revenue ranges are shown in the columns of Table 5. The growth rate seems to fluctuate notably between the ranges, although it needs to be remembered that the average can be highly affected even by one company having large-scale increase or decrease in their growth. The percentages in Table 5 take each company in the ranges into account, but one option would have been to cut out a few of the top and bottom performing companies in each range to get a better mean value.

The best and worst performing companies in each revenue range were presented earlier, so they will not be looked into here. For companies with over 50MEUR revenue, the growth has been impressive with the average percentage being 42.8% and yearly percentage average totalling to 8.6%. The big companies with high revenues are able to make large investments and even corporate acquisitions, which normally have a positive impact on the growth. In 10-50MEUR range the growth has been much more moderate, with the average being 16.9% in 5 years and 3.4% in a year. Even the standout companies in the range did not have big time three-digit growth numbers, which shows how hard it is to gain market share and how tight the competition in the industry can be.

In 2-10MEUR range the growth has once again been remarkable with the average being 46.45% and in a year 9.3%. Here the spread of the growth numbers between the companies starts to get much more noticeable with some pulling negative growth rates and others having three-digit growth in the timespan. The growth has been the most substantial in the 1-2MEUR range, with the average being 74.2% in 5-year period and 14.8%

in a year. This is due to the hefty three-digit growth by several companies and by only two companies having a slightly negative growth. In the smallest range of below 1MEUR the growth has been the smallest with 14.4% in 5 years and 2.9% in a year. Many of these companies are owned by private entrepreneurs and only employ 1-10 persons, which makes it hard to compete against the big competitors in the industry.

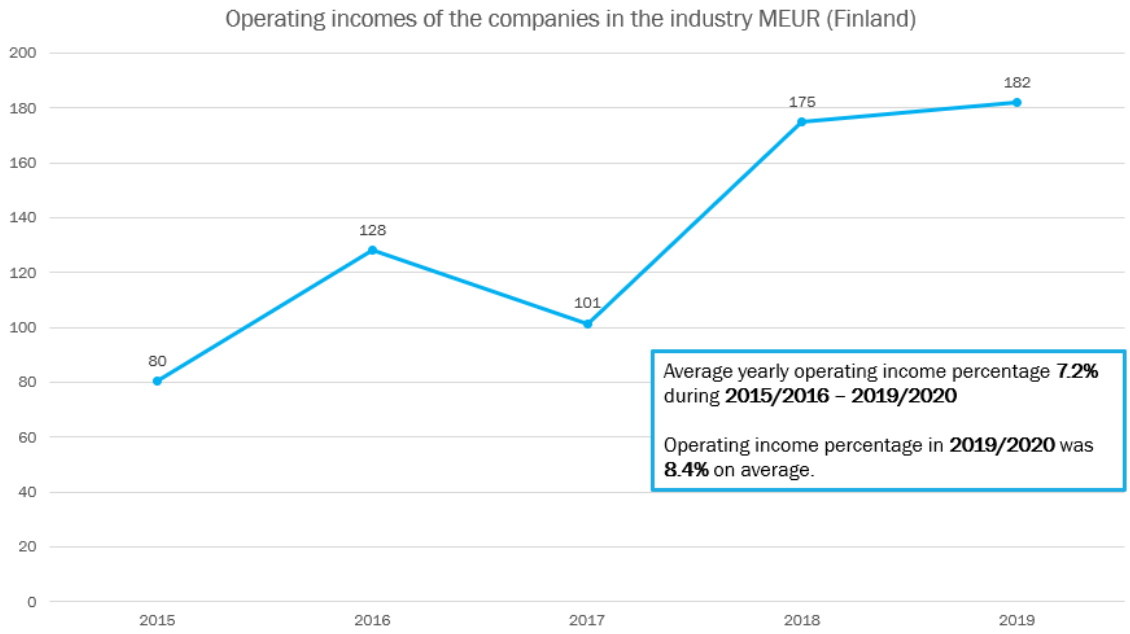


Figure 28. Total operating incomes of the companies during 2015-2019.

The overall growth of operating income in the Finnish material handling companies is shown in Figure 28. The growth has not been as direct as it was in terms of the revenues, and the decrease in 2016-2017 has been even bigger than compared to the revenue trajectory. The average yearly operating income growth percentage has been 7.2% during the timeframe and in 2019/2020 it was 8.4% on average, which shows that the yearly growth percentage has grown slightly. As can be expected, the two biggest companies take up a lion's share of the total operating income as well. For Cargotec, the operating income in 2019 was 37.4MEUR and for Konecranes 75.3MEUR, while the total of all of the companies was 182MEUR. The bigger drop from 2016 to 2017 can also be explained by the results of these two biggest companies. For Cargotec, operating income dropped

from 16.8MEUR in 2016 to 3.3MEUR in 2017, and for Konecranes from 50.9MEUR in 2016 to 36.4MEUR in 2017. This big drop in the results of these two companies has a very visible effect on the overall operating income of the companies as well.

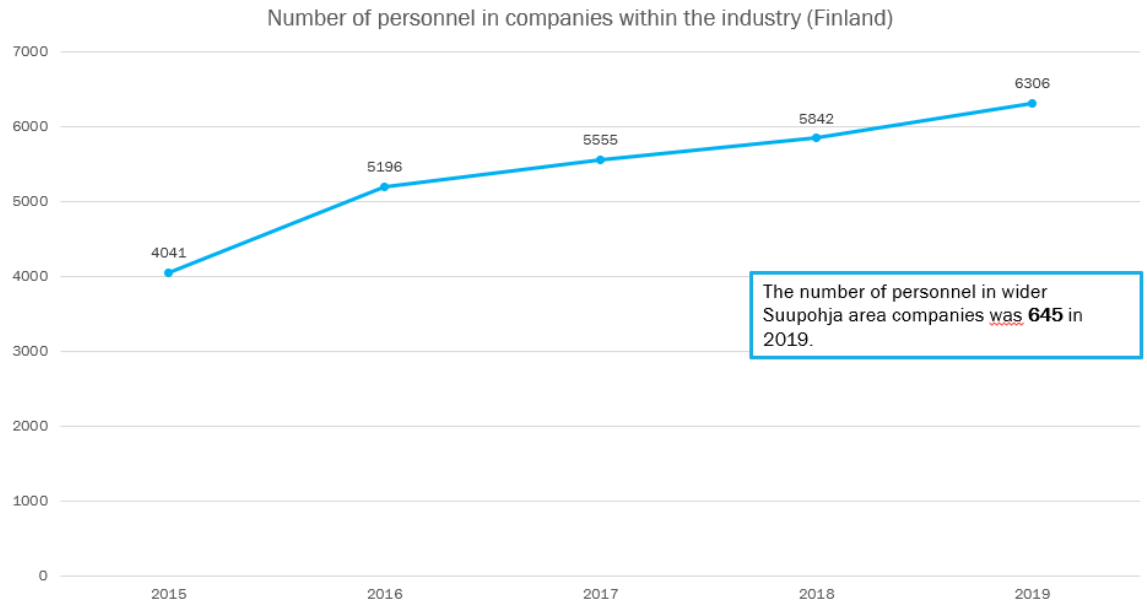


Figure 29. Total number of personnel in Finnish material handling companies.

The total number of personnel in the companies is presented in Figure 29. Here the trajectory has been upwards each year, even though in terms of revenue and operating income there were a few visible bumps. As the companies are able to improve their results in terms of revenue and overall growth almost continuously, more and more personnel are needed each year to cope with the increasing workload. In 2019 the number of personnel in wider Suupohja area material handling companies was 645 persons.

4.3.5 Suupohja companies

This section briefly introduces the material handling companies that are located relatively close to the Suupohja region, which in this study is referred to as the wider Suupohja area. Most of these companies were already presented earlier when going

through the Finnish companies and their financial figures, which is why they will not introduced more thoroughly here.

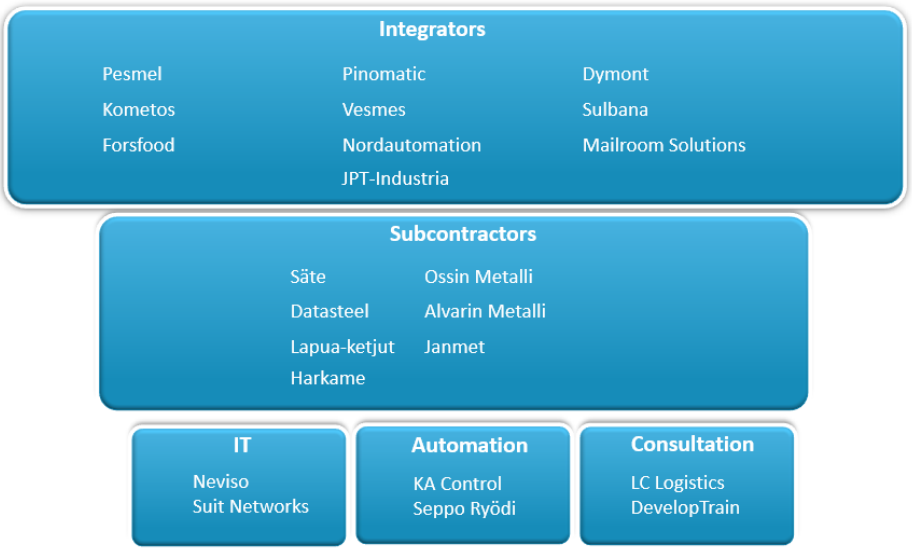


Figure 30. Wider Suupohja region material handling companies.

All the material handling actors in wider Suupohja region are shown in Figure 30. The division has been done based on how the companies are placed on the overall supply chain in the area and what the company's role is. Integrator companies are the so-called top companies, who deliver end-use material handling solutions to their customers and have several subcontractors. Most of these companies also have notable amounts of revenue and they can be considered as big players in the area. Subcontractors, on the other hand, are companies who do not necessarily deliver actual material handling solutions but instead only manufacture individual components for a material handling solution and focus mainly on production only. Because of this, most of these companies (Säte, Datasteel, Lapua-ketjut, Harkame, Alvarin Metalli) were not taken into account in the overall study and their performance was not showcased earlier. These companies are still presented here as the criteria for Suupohja companies was not as strict and all of the actors related to the industry were wanted to be showcased.

Information technology, automation and consultation companies have been put into their own boxes in Figure 30 to display their role in the supply chain. In Suupohja region, there are two actors in each of these sectors and although these companies are specialized in a particular field of the industry, they can all be considered to be material handling companies. These are all relatively small actors with minor revenue, which is why they are not part of the integrator companies. Overall, the total amount of revenue of the Suupohja area material handling companies was about 136MEUR and operating income around 5.7MEUR in 2019.

4.4 Questionnaire results

The last section of the study included conducting a questionnaire for the companies working in the industry and concluding a summary of the results. The idea of the questionnaire was to get a better perception on the market, technology, and main solutions in material handling. Respondents answered the questions mainly based on their own company's perspective, which needs to be remembered when summarizing the results. The specific field of the industry as well as product scopes and solutions of the companies differ, which also leads to having varying answers to the questions. The results were gathered by phone interviews during spring 2021.

The questions that were presented to the companies are listed below:

- What are the key material handling solutions and features of the 2020s?
- Where does the industry compete geographically?
- How do you see the life cycle of the products?
- What are the key technologies in the industry?
- What are the customer criteria when choosing products?
- What are the key machines of the delivered solutions?

In terms of key material handling solutions and features in 2020's, increased demand for automation and digitalization solutions was the most common answer by the

respondents. These two terms go hand in hand and according to the respondents many of their processes are yet to be automated. The integration of individual programs and ERP will also be crucial in automating production processes and optimizing material flows. The consensus was that by automating certain processes and increasing the amount of networking and digitalization, companies are able to enhance other operations with small extra investments as well. The increased use of camera technology and computer vision in inspecting processes was also seen as a major factor during the ongoing decade. The importance of investing in R&D was also mentioned, as the requirements and standards for the products of the companies are constantly increasing, which leads to further development.

The answers related to the geographical competition in the industry varied between the companies, which is to be expected as the product scopes differ. Most of the respondents mentioned that the competition is worldwide and big economies from Asia, such as China and India were brought up. According to one respondent, in the future it will be important to operate also locally in these big economies as localized aspect is needed in regional competition. Big economies want the competition to operate in their marketplace, which leads to the companies need to function in several different business areas if possible.

Regardless of this, according to the majority of the respondents the main competition for their company still comes from Europe and especially other Nordic countries. Specific countries were mentioned depending on the respondent, but there was no clear consensus that a certain country in Europe can be seen as the biggest competing area. USA and Canada were also mentioned individually, but the companies from these countries were seen mainly as local competitors in North America region and therefore not as major threats in the industry. Most of the respondent companies work in a niche business within material handling industry, which is why only one third of the companies mentioned Finland as a major competing region. Many of the competitors within Finland are mainly distributors and do not have their own manufacturing facilities. In conclusion it

could be said that the competition is global and there are local competitors no matter where you go.

The life cycle of the products was another question where the product scope of the companies had a big effect on the answers. Recyclability of the products was one of the main terms that came up regarding the life cycle. These days many customers demand that the products can be recycled after they have been taken out of operation. Many respondents also mentioned that for the time being, most of the needed materials are so cheap that often it is more beneficial for the customer to purchase totally new equipment rather than update or fix the old ones. Nonetheless, repair and upgrading projects of material handling equipment of the companies are still popular as it can be a simpler solution from the customers point of view and circular economy principles are appreciated. Specific parts of a production line or conveyor are modernized, and automation is increased as best as possible to increase overall life cycle. One respondent mentioned that the long life cycle of the products can also be seen as a negative factor, as the need for replacements is not very frequent.

Software and data and their maintenance and upgrading was also mentioned. These days many systems have some sort of software integrated, which leads to companies offering extra services towards them. This causes existing systems and software to be developed and improved much further than earlier. In conclusion, the general consensus was that the life cycle of the products is normally in the range of 10-20, sometimes even 30 years in heavy industry. In smaller systems or entities like automation and IT the life cycle was seen as much shorter, about 5 years.

The question regarding the key technologies in the industry brought up similar answers as the one related to key material handling solutions and features in 2020's. Automation was the term that was mentioned the most and the need for automation was seen to accelerate no matter which specific field of material handling the respondent company operated in. Digitalization and software were also specified once again and one

respondent particularly mentioned computer vision applications as ground-breaking technology in the 2020's. The opinion was justified by the fact that due to the technology the need of employees for this type of observation tasks decreases and the whole system can be controlled by a smaller team. In a bigger, worldwide perspective, trends like robotization, AGVs and high-rise storehouses were mentioned. These were seen as the central technologies in the future, although majority of the respondent companies did not utilize them at the moment.

When talking about the customer criteria for the products, carbon dioxide (CO_2), carbon footprint and environmental aspects in general were mentioned by majority of the respondents. Nowadays it is normal for customers to demand certain environmental requirements from the products and many kinds of emission and carbon footprint papers need to be filled by the supplying companies. Supplying companies are also in increasing manner trying to focus on environmental manners and reducing emissions that their own manufacturing processes produce. According to one respondent, this means, for example, minimizing the use of hydraulics in production lines and converting them to electrical alternatives. The usage of all sorts of oils are also being reduced.

The price of the investment is obviously always an effecting factor, but according to the respondents, other qualities appreciated by the customers, such as availability, durability and reliability being on a high level allows the supplying companies to charge more price for their products. Basically, if the products are of great quality and allow production processes to run smoothly without any stoppages, the customers are willing to pay for it and price is not one of the most important factors. This is the occasion especially with big customer companies. Related to the price, customers are also interested in payback period, life cycle and life cycle costs of the products. The customers want the investment to cover the original purchase cost in a timely manner and a long life cycle means that the need for purchasing a replacement product is infrequent.
Most of the companies manufacture different sort of conveyor or production line solutions for material handling, which is why hygiene was also brought up as an

important customer criterion. This is especially the case for the companies who manufacture solutions for the food industry, where the hygiene standards have to be on a very high level.

People are still in a key position when doing business, which is why clients base their decisions partly on the people providing the service in the supplying company. This leads to people being considered as a criterion as well. For example, Finnish people are not very social, which can hinder the selling process to some extent, even though the products could be of high quality. Plenty of time is often spent discussing about the most suitable solution for the customer, but the needed contacting is often lacking after that phase. Overall, communication towards the customer is essential, which is sometimes forgotten, or the way of contacting could turn out to be unsuccessful. Acquisition of customers, great customer service and quick reaction to customer needs and requirements are important for every business.

The question regarding the key machines of the delivered solutions provided very differing answers. The main verdict was that the key machines in the wide range of material handling industry are very application specific and are dependent on the precise field of the industry, which is why certain machines cannot me defined for the whole industry. Most of the respondent companies cannot be considered as major players in the global material handling markets and as they answered mostly based on their own company's point of view, the key machines were very different compared to the global standpoint and can be used to determine the stage of the industry in the specific area. Many of the respondent companies deliver big solutions, such as entire modules and systems, which is why many of them found it difficult to mention what are the specific key machines in the delivered solutions. Most of the companies also do not have standard products and are mainly focused on manufacturing special machinery according to varying customer demands. For the respondents who pointed out certain equipment, answers varied from pulverizing machinery to feeders and dosing machines.

From a global point of view and in terms of the entire material handling industry AGVs, robots and high-rise storehouses were seen as the main machines in the industry in 2020's. The big global players in the industry that were mentioned in section 4.2 are already making the most of these technologies in their production facilities and in finished products as well. The overall trends of automation and digitalization were seen as the main driving forces in the industry, which can be seen from the key machines as well. Even though the above-mentioned equipment were mentioned by the respondents very quickly when talking about the global markets, most of the respondent companies admitted to not utilizing or utilizing them in only a minor manner currently. That said, respondents thought that these types of equipment will surely become more common in Finland as well in the 2020's, but the utilization level was found to be heavily dependent on the field of the industry as they cannot be very beneficial for everyone.

5 Conclusions

This section summarizes the main findings of the research and provides a conclusion based on the results that were found. The aim of the study was to provide a review on the status of the material handling industry locally, regionally and globally. The study started with introduction, which provided the background, scope, objectives and structure for the study. Literature review section explained material handling as a term, the different types of material handling equipment, material handling technologies and the state of the material handling market. Lastly, the results section provided a deeper look at the key players working in the industry with Finnish material handling companies being the main focus.

As stated in the introduction, the research questions of the thesis were 1) How big is the material handling market and how it is spread globally? 2) Who are the key players in the industry, what kind of products they manufacture and how they have been doing based on financial figures? 3) What are the equipment and technologies used in the industry now and in the future? 4) What should the Suupohja region companies do to remain competitive in the industry?

To answer the first research question about the material handling equipment market, it can be said that the future of the industry looks bright. The size of the market was estimated to be around 140-200 billion USD in 2019 with an average CAGR of 5-6% all the way to 2027. From a geographical point of view, Asia Pacific region is the biggest player in the industry and is expected to become an even more dominant market leader due to the adoption of modern material handling methods. North America is anticipated to grow substantially, whereas Europe, Middle East and Africa are expected to grow moderately or consistently. Although the COVID-19 pandemic has had a negative impact on the industry as can be expected, the market is anticipated to recover during 2021 with the growth of e-commerce being the biggest driving force. Cranes and lifting equipment hold majority of the market share but the growth of the industrial truck sector is expected to be the most considerable.

The second research question about the key players, their products and financial figures was presented widely in the results section. The three biggest material handling companies worldwide based on revenue are Daifuku, Schaefer and Dematic. Many of the biggest companies worldwide are able to supply products for all material handling needs versatilely. Half of the 20 biggest companies experienced double-digit percentage growth in 2019 and only four had a decline in their revenue. In terms of Finnish companies, Konecranes and Cargotec are clearly the biggest players in the industry in Finland and can be considered as major players even on a global scale, especially due to the currently pending merger of these two companies. When talking about the products that the Finnish companies manufacture, there are three sectors that clearly stand out. These are conveyors (29%), forklifts and lifters (22%) and automation, robotics and programming (20%). For Finnish material handling companies, the average increase in revenue during the 5-year study period was 39% with an annual 7.2% growth in operating income, which shows the steady growth of the industry.

To answer the third research question about the equipment and technologies in the industry, the findings of the thesis suggest that the level of automation and automatic or semi-automatic solutions are constantly becoming more popular in material handling. The material handling industry consists of a large number of equipment that are used for moving the material from one place to another. Although many of the equipment still utilize some sort of mechanical work, majority of the preferred material handling solutions are becoming either semi-automatic or fully automatic. In terms of technology, the practices and technological pillars of Industry 4.0 are implemented increasingly by organizations aiming for smart manufacturing facilities. The practices consist of characteristics such as adaption, automation, digitalization and optimization. This includes taking advantage of technologies like IoT, Big Data Analytics, RFID, autonomous vehicles and robotics. The estimated adoption rates of the technologies suggest that most organizations are going to utilize them during the next 1-2 years. Due to the popularity of Industry 4.0 practices, everything is transitioning towards a digitally enabled and data-driven world, which requires finding the correct tools to utilize it in the best possible way.

Nowadays organizations are able to recognize the benefits that can be acquired by implementing effective material handling practices. The main advantages of having viable material handling solutions are that they help with reducing operating expenses and increase the overall efficiency of an organization. These solutions are also able to reduce industrial problems such as the need of humans for work tasks that involve physical drudgery. Material handling operations can generate over 50 percent of the operating expenses of an organization, which is why careful cost comparison and weighing of the costs is needed when choosing the best possible solutions for an organization. The safety aspect in material handling should also not be forgotten as the handling of material account for over half of industrial accidents.

To answer the final research question of the thesis, it can be said that in order for the Finnish and especially Suupohja region companies to be able to compete in the industry in the future, it would be important to:

- Utilize the trends of automation, digitalization and other Industry 4.0 practices to a higher extent in manufacturing facilities and products.
- Take into consideration the changing customer criteria for products, such as CO_2 emissions, electricity consumption, recyclability and environmental perspective in general.
- Developing advantageous synergies between companies in the same region and investigating the possibility of mergers to create substantial players for the global markets.
- Have the ability to manufacture industry specific special purpose solutions and turnkey systems in addition to the standard solutions.
- Developing software around the supplied material handling solutions – Software as a Service (SaaS)

In the future it will be important to conduct this kind of studies on a regular basis to get a good and relevant overview about the status of the industry and of the degree in which the above-mentioned trends and practices are implemented globally. The companies participating in the research group are able to take advantage of the findings presented in the thesis and future studies could be based on further needs of the companies within the industry. In the future, the scope of this kind of study can be broadened to cover other regions, for example in Finland.

References

ABI Research. (2019). *Whitepaper | How to Optimize Digital Transformation in Manufacturing Companies.* Retrieved 1.9.2021 from https://go.abiresearch.com/lp-optimizing-digital-transformation-in-manufacturing

Bhat, K. S. (2009). *Materials Management (4th ed.)* Himalaya Pub. House.

Bond, J. (2020). *Top 20 Materials Handling System Suppliers 2020.* Retrieved 8.4.2021 from https://www.mmh.com/article/top_20_materials_handling_system_suppliers_2020

Breque, M., De Nul, L., & Petridis, A. (2021). *Industry 5.0 Towards a sustainable, human- centric and resilient European industry.* doi:10.2777/308407

Cargotec. (2020). *Cargotec and Konecranes to Merge Creating a Global Leader in Sustainable Material Flow.* Cargotec. Retrieved 14.4.2021 from https://www.cargotec.com/en/nasdaq/stock-exchange-release-kalmar-hiab-macgregor/2020/cargotec-and-konecranes-to-merge-creating-a-global-leader-in-sustainable-material-flow/

CAT Lift Trucks. (2021). *EP16-20A(C)N Electric Forklifts.* CAT Lift Trucks. Retrieved 16.9.2021 from https://www.catlifttruck.com/products/counterbalance-forklift-trucks/electric-powered-forklift-trucks/ep16-20acn

Dematic. (2018). *Dematic AGVs.* Retrieved 16.9.2021 from https://www.dematic.com/en-us/downloads-and-resources/brochures/download/?map=1&id=1651

Edirisuriya, A., Weerabahu, S., & Wickramarachchi, R. (2018). *Applicability of Lean and Green Concepts in Logistics 4.0: A Systematic Review of Literature.* doi:10.1109/POMS.2018.8629443

Efthymiou, O. K, & Ponis, S. T. (2019). *Current Status of Industry 4.0 in Material Handling Automation and In-house Logistics*. International Journal of Industrial and Manufacturing Engineering. doi:doi.org/10.5281/zenodo.3566333

elcom. (2021). *Roller conveyors - elcom - conveyors for industry.* elcom - conveyors. Retrieved 16.9.2021 from https://elcom-automation.com/conveyors/roller-conveyors

Fortune Business Insights. (2020). *Material Handling Equipment Market Size, Growth | Industry Report, 2027.* Retrieved 3.9.2021 from https://www.fortunebusinessinsights.com/industry-reports/material-handling-equipment-market-101501

Furmans, K., Seibold, Z., & Trenkle, A. (2018). *Future Technologies in Intralogistics and Material Handling*. *Operations, Logistics and Supply Chain Management*. Springer International Publishing. doi:10.1007/978-3-319-92447-2_24

Global Market Insights. (2021). *Material Handling Equipment Market Size Statistics 2027.* Global Market Insights, Inc. https://www.gminsights.com/industry-analysis/material-handling-equipment-market

Hokkanen, S., Karhunen, J., & Luukkainen, M. (2011). *Johdatus logistiseen ajatteluun* (6. uud. p. ed.). Sho Business Development.

institute of Entrepreneurship Development. (2019). *The 4 Industrial Revolutions*. Retrieved 8.6.2021 from https://ied.eu/project-updates/the-4-industrial-revolutions

KITO Erikkila. (2021). Yritys. Retrieved 19.4.2021 from https://www.erikkila.com/fi/about/

Market Research Future. (2021). *Material Handling Equipment Market Size, Share, Growth | Report, 2027.* Retrieved 2.9.2021 from https://www.marketresearchfuture.com/reports/material-handling-equipment-market-3214

MHI. (2019). *Handling the US Economy: The Economic Impact of the Material Handling Industry.* Retrieved 13.9.2021 from https://www.mhi.org/learning/market-research

MHI. (2020). *2020 MHI Annual Industry Report - Embracing the Digital Mindset*. Retrieved 2.9.2021 from https://www.mhi.org/publications/report

MHI. (2021). *2021 MHI Annual Industry Report - Innovation Driven Resilience*. Retrieved 2.9.2021 from https://www.mhi.org/publications/report

Ray, S. (2008). *Introduction to Materials Handling*. New Age International Publishers. ISBN: 978-81-224-2554-3.

Saturno, M., Pertel, V., & Deschamps, F. (2017). *Proposal of an automation solutions architecture for Industry 4.0*. doi:10.12783/dtetr/icpr2017/17675

Spectral Engines. (2018). *Industry 4.0 and how smart sensors make the difference.* Retrieved 29.5.2021 from https://www.spectralengines.com/articles/industry-4-0-and-how-smart-sensors-make-the-difference

Stephens, M., & Meyers, F. (2013). *Manufacturing Facilities Design and Material Handling*. ISBN-13:978-1-55753-650-1.

Suomen Asiakastieto Oy. (2021). Retrieved 26.4.2021 from https://www.asiakastieto.fi/web/fi/etusivu.html.

Tjahjono, B., Esplugues, C., Ares, E., & Pelaez, G. (2017). *What does Industry 4.0 mean to Supply Chain?* Procedia Manufacturing. doi:10.1016/j.promfg.2017.09.191

Uproval. (2021). *Company – Uproval*. Retrieved 17.4.2021 from https://uproval.fi/company/