jamk.fi

How Artificial Intelligence can affect postal and parcel industry

Anh Nguyen

Bachelor's thesis
December 2020
School of Technology
Degree Programme in International Logistics

Jyväskylän ammattikorkeakoulu
JAMK University of Applied Sciences

jamk.fi

Description

Author(s)	Type of publication	Date
Nguyen, Anh	Bachelor's thesis	December 2020
		Language of publication: English
	Number of pages 65	Permission for web publication: x

Title of publication

How Artificial Intelligence can affect postal and parcel industry

Degree programme

International Logistics

Supervisor(s)

Pesonen, Juha; Franssila, Tommi

Assigned by

JAMK University of Applied Sciences

Abstract

Nowadays, Artificial intelligence plays an increasingly prominent and interactive role in many industries. Artificial intelligence could improve capacity, reliability, energy efficiency, flexibility, safety, and cost effectiveness. In postal and parcel industry, Artificial intelligence could improve the efficiency of transportation and optimize performance in warehousing operation. By collecting and analyzing data, AI could predict inventory, flows of materials, demand and supply, as well as other factors between business and technology.

The objectives of the thesis are examined how Artificial intelligence technology could impact the daily operations of postal and parcel industry by using self-driving vehicles, robotics, automated machine to communicate with clients and customers, assist supply chain planning, improve transportation and warehouse management.

The method was used in this study in order to achieve the objectives is qualitative method through observations, collected and analyzed data from academic articles, books, internal publications, research studies.

Although Artificial Intelligence dramatically enhance our world, support our lives, made the huge potential benefit. However, there are some concerns about labor market and economic issues were also researched in the thesis.

In conclusion, the study could generalize the general picture how Artificial intelligence revolutionizing the supply chain planning, logistics operations, transportation and inventory management. This also demonstrated with the rapid development of artificial intelligence, it will be disruptive human work. Consequently, businesses and government need to help employees retrain and adapt to new technology trends.

Keywords/tags: Artificial intelligence, automation, robotics, logistics, warehouse, transportation, labor.

Miscellaneous

Contents

1 Introduction 4

1.1 Purpose and goals, objectives of the thesis 4

1.2 Methodology and research 6

2 Fundamentals of Artificial Intelligence 7

2.1 History of Artificial Intelligence 7

2.2 What is Artificial Intelligence? 10

2.3 Types of Artificial Intelligence 13

3 The demand of AI technology in logistics operation 14

3.1 Demand of AI in postal operation 14

3.2 AI in distribution centers 17

3.3 AI in sorting letters and parcels 18

3.4 AI in last mile delivery 19

4 Implementation of AI in postal and parcel industry 21

4.1 AI technology in warehousing operations 21

4.1.1 Barcode 22

4.1.2 Radio Frequency Identification (FRID) 23

4.1.3 Robotics 24

4.1.4 Computer vision and sensors 26

4.2 AI technology in delivery 27

4.2.1 Autonomous Vehicles 27

4.2.2 Drones/unmanned aerial vehicles (UAVs) 29

4.2.3 Smart lockers 31

5 Case of implemented of AI in the postal industry 32

5.1 Case of AI technology in distribution centers and sorting 32

5.1.1 Belgium postal service Bpost and computer vision 32

5.1.2 Portugal postal service and autonomous robots 34

5.2 Case of AI technology in delivery 36

5.2.1 Starship autonomous robots in last-mile delivery 36

5.2.2 French postal service using drones to delivery parcels to remote areas 38

6 Challenges of AI adoption in postal operation 40

6.1 Impact of AI in labor market 40

6.2 Impact of AI in economic issues 43

7 Discussion 46

7.1 Research results 46

7.2 Future further research 49

References 50

Appendices 57

Appendix 1: The table of resources to collect data for research 57

Appendix 2: Logistics trend radar (DHL) 60

Appendix 2. Development of digital postal services in Europe and CIS (UPU) 60

Appendix 3. AI application in the warehouse (DHL) 61

Appendix 4: Delivery Robots (UPS) 62

Appendix 5: Warehouse Robots (UPS) 62

Figures

Figure 1. Timeline of Artificial Intelligence Technology 9

Figure 2. Categories of definition of Artificial Intelligence 11

Figure 3. Artificial Intelligence Term 12

Figure 4.Types of AI and their progression 13

Figure 5. Cost Driver in the Supply Chain 20

Figure 6. Consumer Demand Survey 21
Figure 7. Type of barcodes 22
Figure 8. RFID frequency charateristics 23
Figure 9. DHL Smart Sensors RFID 24
Figure 10. Kiva robots at Amazon warehouse 26
Figure 11. Sensing technologies in autonomous vehicles 28
Figure 12. DHL Drone 30
Figure 13. Posti Parcel Locker 31
Figure 14. TugBot and Kuka robots at CTT sorting center 35
Figure 15. Starship autonomous robot 36
Figure 16: RoboVan by Starship and Mercedes-Benz 37
Figure 17: La Poste Drone 38
Figure 18: The comparision between delivery by truck (red line) and delivery by drone (green line) 39
Figure 19. Potential impact of automation in labor market and economic issues 40
Figure 20. Impact of job automation by gender and education level 41
Figure 21. Impact of job automation on industry categories 42
Figure 22: Labor cost compare robot prices (1990=100%) 45

1 Introduction

The purpose of this study was to provide an overview of Artificial intelligence (AI) impact to postal and parcel industry in the present and the future. The main research focus on AI technology applications has grown strongly based on trends demanded by the market. Reliability of research of data from case studies are mostly sourced from European postal companies.

1.1 Purpose and goals, objectives of the thesis

Artificial intelligence today is no longer a strange concept. It is not the science fiction commonly seen in movies and books anymore. The past decade has seen the rise of Artificial Intelligence with investment at a high rate. In 2016, companies spent $ 26-39 billion on AI (Joerss, Klink, Mann, Neuhaus, & Schröder, 2016). AI's application appeared everywhere in the real world. AI can be used in numerous fields and industries: transportation, manufacturing, healthcare, education, media, customer service. In the field of logistics and supply chain, companies have used AI to enhance and automate the process of creating supply chains (Petropoulos, 2018). Thanks to AI, supply chains processes such as demand forecasting, predictive maintenance, and production planning can be automated.

Will AI replace humans in workforce? How to make humans and robots coexist? Do we need a morality for AI? Could robots become dangerous for humans? What is the position of a robot by relationship to a human in our society? If a robot is endowed with consciousness and emotions, is it slavery to use them? The long list of questions that are currently being asked in newspapers, in conferences, in research centers. But all these questions relate to highly developed AI, AI rising to the level of human intelligence. It is this level, general AI, that is currently the focus of many researchers, businesses and governments. Of course, this leads to many debates about what is AI and what its characteristics are, how to be applied to real life. For the rest of this study, when discuss about AI, it will refer to the form of narrow AI.

The aim of this study is to examine how the applications of AI is being implemented in postal and parcel industry. Moreover, it also investigates how AI is changing the market of postal operation. For research purpose, examples of implementing AI technology in warehouse operation and last-mile delivery are presented in chapter 5 with case studies from national postal companies in Europe (France, Belgium, Portugal, Switzerland and Estonia).

Global E-Commerce platforms are growing and blooming with unprecedented rate, people from all age and gender love to shop online. Instead of spending time and effort go out shopping at the physical store, they can buy everything on e-commerce sites, literally. A few days later the goods will be delivered to their door. E-commerce market in Europe in 2019 is worth 344 billion EUR (Copenhagen Economics, 20) and is expected to reach 374 billion EUR at the end of 2020 with almost 70 percent of the European internet users shopping online. E-commerce will grow by 17% per year, which will represent about 20% of global retail share in 2023 (Ecommerce Statista, 2020). As a result, it leads to an increasing volume of mail and parcels being transported across Europe both domestically and across borders. In response to this change, postal and parcel services are in a race to be able to optimize their operations and deliver goods on time to a right place to provide customer satisfaction. The company can reduce traffic, improve operation efficiency, faster delivery and it will lead to more profits.

In modern warehousing operations, robots may perform tasks that are risky, tedious or repetitive, allowing people to focus on things that required creative and less manual. Thus, people can have a better and easier life thanks to the implementation of AI. Besides the potential benefits AI bringing to the world of logistics, there some challenges are shown below.

The overall purpose of the thesis was to determine the important role of AI in postal industry, identify benefits of AI to logistics sphere, how AI will affect in sorting process as well last-mile delivery and risk when implementing AI. More specifically, in order to reach these objectives, the following research questions will need to be addressed below:

- What is AI and how AI is becoming the game changer in postal industry?
- How the AI is applied in postal and parcel industry?
- Which postal and parcel companies are adopted AI technology?
- How will AI change postal and parcel services in the future?
- What are advantages and disadvantages of AI in logistics?
- What challenges do companies will take when implementing AI in operation?

1.2 Methodology and research

The primary research method was used for this study is qualitative method. Qualitative research usually approaches the research subjects most naturally, in order to ensure the behaviors, opinions and views that the research subjects make will be most objective and accurate. Qualitative research requires creativity and flexibility. However, research cannot rely solely on the raw data obtained from a survey to write a report or draw conclusions. It combines with grounded theory, thematic analysis and discourse analysis. (Aspers, 2019, 139)

The choice of the case study is not dependent on the chosen research approach, qualitative or quantitative, but depends more on what we wants to study (Stake, 2008). In this situation, the research study the phenomenon of the integration of AI solutions in postal industry. This represents a phenomenon that can be generalized to several situations. The thinking therefore does not come from an intention to study a particular case for what it is, but rather to use a case as a tool to better understand this phenomenon. This approach corresponds to the category of instrumental case of Robert Stake. The case studies coupled with semi-structured interviews, which can be seen in the rest of this study, open the possibility of collecting information directly from people who have experienced the AI revolution (Stake, 2008). This method seems to satisfy our objective of bringing the necessary nuance to the study of the impact of AI solutions on the companies through the understanding of the reality constructed by the relevant parties that we want to study.

The aim of extensive literature search and review is to gain an appropriate understanding of the themes. The research is to understand the effects of introducing AI solutions into postal service. The goal is to go beyond more traditional visions that focus on the economic efficiency of organizations, it also studies the effects from different perspectives, bringing in the notions of relationships and values between AI and people. In order to verify the research, study will base on the four postpositivist criteria of Egon and Lincoln (1994, 105) which require research to be credible, transferable, dependent and confirmable. The data was mainly collected and analyzed data from academic articles, videos, books, logistics journals, research studies. The research based on a comprehensive review of current postal industry internal publications and academic researches. Additional, illustrative tables and statistical calculation charts will also be presented.

This study also showed the opportunities and challenges of using artificial intelligence techniques in the world of postal logistics and supply chain sphere. The literature review will be based on research questions, case studies and from all data was collected from reliable sources as can be seen in appendix 1.

2 Fundamentals of Artificial Intelligence

2.1 History of Artificial Intelligence

The advent of computers seems to make the AI dream possible. The two approaches to AI will emerge in the 1940s: connectionism and cognitivism. Cognitivism considers that thought can be described at an abstract level as a manipulation of symbols, independently of the material medium of this manipulation (brain, electronic machine). This approach establishes a link between thought and language (system of symbols). A “top-down” approach to cognitivism is to allow machines to manipulate language, assuming this will make them intelligent (Smolensky, 1987). From the 1950s onwards, programs developed at that time were considered "extraordinary"

by most people: computers solving algebraic problems, proving theorems in geometry and learning to speak language. (Perez, Deligianni, Ravi, & Yang, n.d)

In 1920, the Czech playwright Karel Capek produced a science-themed play called Rossum's Universal Robot (RUR), which revolved around a factory that produced human beings created, named the robot. In RUR, robots were originally born to work for humans, but then rebelled and led to the extinction of humankind. (Schultebraucks 2018)

The idea of building an AI program first appeared in October 1950, when British scientist Alan Turing considered the problem of "Can machines think?" To answer this question, he came up with the concept of "mimicry test" which later became known as the "Turing test". The test is performed in the form of a game. Accordingly, three subjects participated in the game (consisting of two people and one computer). One person (interrogator) sat in a separate room separate from the other two subjects. One person asks questions and receives answers from the other (interrogator respondent) and from the computer. If we cannot distinguish from a conversation with a human being, then the machine can be called "intelligent" (Buchanan 2006)

In 1955, John McCarthy, an American computer scientist and cognitive scientist from Stanford University, first came up with the concept of Artificial Intelligence, which means the science and engineering of manufacturing intelligent machines. A year later, he hosted the Dartmouth Conference, the first conference on this topic. Experts from various universities and companies such as Carnegie Mellon University, Massachusetts Institute of Technology and IBM participated in the conference. Since then, the concept of "artificial intelligence" has been widely used. (Schultebraucks, 2018)

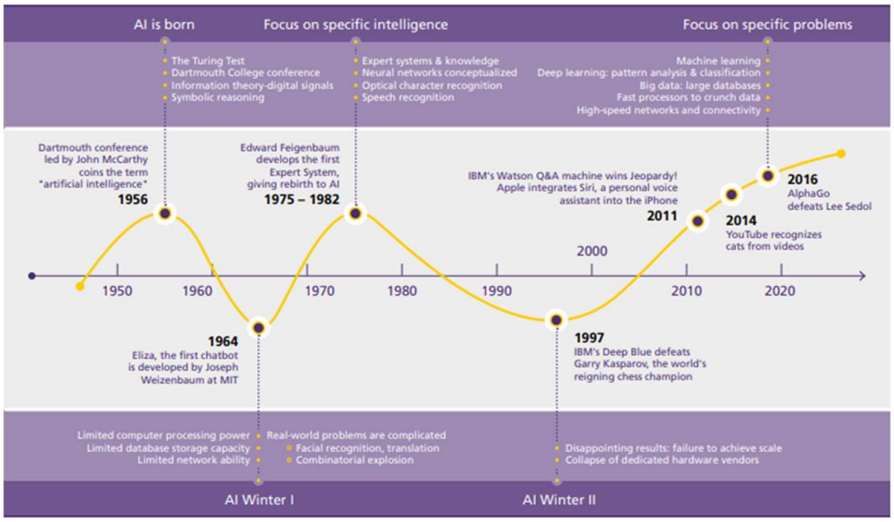


Figure 1. Timeline of Artificial Intelligence Technology (DHL, 2018)

During its historical development, the science of artificial intelligence research went through the following stages as depicted in figure 1. Mid 1960s, AI got beginnings with many exciting research movements, it has promising results but difficult to obtain

In 1974s is first interrupt, AI winter with frustration, disorientation and lack of funding. Researchers during this period failed to handle the more complex problems of AI. At the same time, machines in this period were a major barrier to the development of artificial intelligence, when the computing power of machines was not large enough to calculate the amount of data that at the time was thought to be large and complex. From 1987 to 1997 is second AI winter, AI falls into a period of hiatus and difficulty, typical of a developmental loop - the recession of an economic bubble. (Flasiński 2016, 3).

1984. Ernst Dickmanns from Bundeswehr University in Munich and Mercedes-Benz test an automatic van equipped with cameras. The vehicle reaches 100 km / h on a road network without traffic. The driverless car is now almost operational. (Lantos, & Márton)

Late 90s and early 21st century: Success with new approaches, new funding with the dawn of Machine Learning. AI began to show its power by winning humans in Go game, AI became human assistants. In the past 20 years, AI has developed strongly. The development of AI comes from three different factors: advancements in algorithmic research, an increase in computing power and data explosion. The birth of Deep Learning and Neural Network creates solutions for complex issues such as image recognition and natural language processing. (Flasiński 2016, 4)

In recent years, AI has grown incredible in terms of power, processing speed and problem solving as more and more flexible as humans. AI becomes a big piece of science and technology. It plays an important role, helping to solve many challenges in manufacturing, manufacturing, computer science, software technology, research, and operation to replace labor force and serve the increasing needs of people. (ibid., 5.)

2.2 What is Artificial Intelligence?

Definition of AI is not simple. This field is so large that it cannot be narrowed down to a specific area of study, rather it is a multidisciplinary program. While AI's initial ambition was to mimic human cognitive processes, AI's current goal is to develop automated robots that solve certain problems better much more than human. We can compare the functioning of a machine learning algorithm to the cognitive development of the child: the child learns by observing the world, by analyzing the way in which individuals interact, by reproducing the rules without actually exposing them explicitly to him. Basically, the same thing happens with machine learning: algorithms are now trained to learn on their own without explicit programming. (Perez, et al. n.d). There are as many definitions of artificial intelligence for example:

AI is a term intelligence displayed by machines, as opposed to the natural intelligence shown by humans or animals. It means that the intelligence of computers is created by human programming with the goal of helping computers achieve intelligent behavior of automation like humans. Humans use machine learning systems to make

computers capable of simulating human intelligence. Artificial intelligence is a complex concept that refers to the ability of machines to perceive and think like humans. The concept of "intelligence" here can include the ability to logic, comprehension, self-awareness, learning, emotions, creativity and problem solving. (Advani 2020)

"Artificial intelligence is a set of algorithms and intelligence to try to mimic human intelligence. Machine learning is one of them, and deep learning is one of those machine learning techniques." (Chen, 2017). Several authors have attempted to define AI as seen in figures 2.

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Figure 2. Categories of definition of Artificial Intelligence (Russel, & Norvig, 2016)

Machine learning is a subset of AI that uses statistical techniques to give computer systems the ability to “learn” from data and improve from experience without being explicitly programmed, divided by 3 different categories: Supervised Learning, Unsupervised Learning and Reinforcement Learning. The learning process begins with observations of data and use iterative algorithms to learn from data. (Kaplan

2016, 27). The goal of machine learning is to give an answer (output) to a question (input) and this through an algorithm trained on a set of data specific to this question. (Ng, 2019).

Deep learning is subdomain of machine learning, these models use many neural networks to build algorithms called neurons, usually arranged in layers successive. According to Geoffrey Hinton, Yann LeCun and Yoshua Bengio, these neurons are linked together by connections whose importance is adjusted during the learning phase. Each neuron transforms its inputs into an output by applying a transfer function to all the information that reaches it through these connections. Neural networks are systems schematically inspired by the functioning of the brain. They are made up of several artificial neurons connected to each other. The higher the number of neurons, it becomes more complex and loses its transparency and interpretability. After learning, the neural network has broken down the input data into different hierarchical layers of abstraction. Neural networks are particularly efficient in the processing of data similar to signals: sound, image, language, videos because they are capable of capturing complex structures spatially and temporally. (Hinton, Bengio, & Yann, 2015)

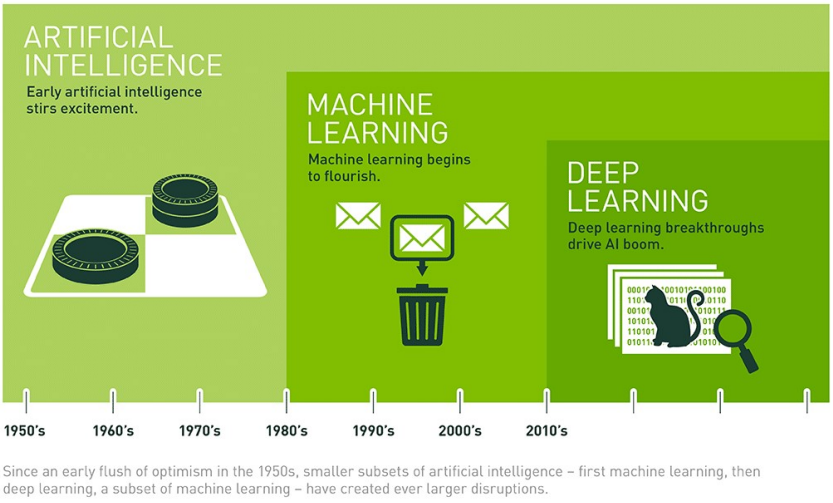


Figure 3. Artificial Intelligence Term (Copeland, 2016)

2.3 Types of Artificial Intelligence

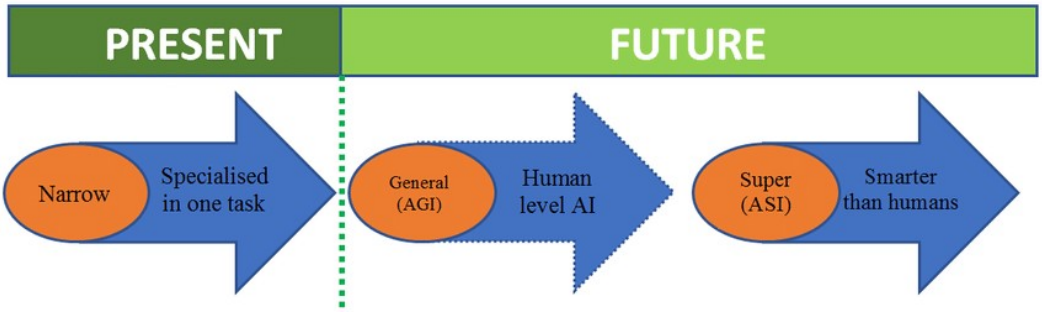


Figure 4.Types of AI and their progression (Harwood, Maltby, & Ladinska, 2019)

AI devided into three types, stage 1 is Artificial Narrow Intelligence (ANI) also known as weak AI dedicated to assist with or take over specific tasks. Following with stage 2 is Artificial General Intelligence (AGI) also known as strong AI takes knowledge from one domain, transfers it to another domain. And finally stage 3 is Artificial Super Intelligence (ASI) machines that are an order of magnitude smarter than humans in practically every field. The ability to use AI nowadays is only limited at narrow AI (Harwood, Maltby, & Ladinska, 2019). Some use cases of AI in supply chain are presented below

Analytics AI: Analyze huge amounts of data to optimize the process and balance between demand and supply. For example, it improves demand forecasting in warehouses and tracks the inventory for efficient supply chain planning. In route optimization, it helps companies reduce shipping cost as well as faster shipping. (Bekker, 2019)

Functional AI: Robotics are a great choice to save money and time. Autonomous robots can pick, sort, bring shelves to workers or even climb the racks. Unmanned aerial vehicles or self-driving cars allow non-stop delivery thereby increasing efficiency. (ibid.)

Interactive AI: This type of AI can help companies have better workflow even when lacking staff. Chatbot or virtual assistant use natural language processing for offering customer 24/7 support. Consequently, customers will need their necessary information anytime they want without waiting for response from staff. Companies then reduce the labour cost in customer support fields. (ibid.)

Visual AI: use computer vision to convert images into digital and help companies identify, recognize, classify and sort items. The camera can read barcodes and decide which way for parcels based on postal code, the sensor can also identify items that are lying in the wrong direction on the conveyor. (ibid.)

3 The demand of AI technology in logistics operation

3.1 Demand of AI in postal operation

The digital revolution has been and is having a strong impact on every industry and every profession in the world. The world postal industry is also being affected by electronic replacement services and e-commerce and is witnessing a drop in mail output, negatively affecting postal revenue. But it is the development of alternative electronic services and e-commerce that bring many opportunities to the postal industry and are creating a huge number of small packages and letters that postal businesses around the world are having to deliver to consumers door to door. (Davis, 1)

In 2016 annual public report, La Poste noted that the continuous fall in mail volumes, which reduced turnover by around € 500 million each year, made major adjustments to the functioning, organization and missions of the postal distribution network essential to ensure its economic viability. (La Poste, 2017)

The postal sector is facing new challenges, such as increasing competitors, new customer demands, the importance of information and communication technologies

(ICT) and pressure on price rates. Postal operators have reacted positively and consider these technologies as an opportunity to modernize the postal sector. In the context of strong development of communication forms on the basis of technology and declining output of traditional postal services, many postal companies have applied IT, invested in technology in production and supply processes service, deeply participate in the e-commerce supply chain to create digital services in post to improve service quality, increase labor productivity, and ensure postal safety. Thereby maintaining and developing the business of traditional postal services to better meet the needs of the government, businesses and people.

Over the last two years, DHL listed numerous factors that can affect to logistics operation industry. The driving trends can be seen at Appendix 2.

According to experts of the World Postal Union (UPU), under pressure from the market, postal services in many countries have soon innovated and provided many digital postal services in 04 main groups: E-post & E-Government services, E-commerce, Payment / e-finance solutions, support services, in which, e-Government support services and e-commerce are effectively implemented by many countries and has a good results (such as Swiss Post, Austria and France). From there, opening more great opportunities for postal businesses to boost their business and improve their competitive position in the market. (See appendix 3)

First of all, new AI technologies are used to improve the parcel and mail-handling process at the postal operation, they are used to improve the collecting, sorting, tracking and last-mile delivering of postal mail. As a result, postal operators want to reduce their costs and increase their efficiency. AI in this industry is the game changer. (Postal Innovation Platform, 22-23, 2017)

AI is also revolutionizing the mailing system. Most of postal operators today uses bar codes as postage stamps. These records information about the sender and recipient addresses, as well as customers request about type of delivery like priority or standard mails. It is allowing for quick sorting at postal centers in addition greater reliability and reduced labor. Some operators, such as USPS, the Italian Post Office

and DHL, are already using very new technology in their mailing systems is Radio Frequency Identification (RFID). Although currently more expensive and less environmentally friendly than barcodes, it offers an opportunity for the postal sector to be innovative. Radio-identification allows letters to be tracked in real time. It can identify letters and parcels delays or missing, find solutions to improve performance. Also, thanks to AI, postal operators hope to revolutionize their logistics. The new strategy consists of vehicles, bags and baskets of letters, and even every postal item with RFID or barcodes. Using detectors in the sorting center, information on the location of the mail or its destination is sent to a server. This real-time centralization of information allows better allocation of resources. For example, vehicles are automatically registered at the entrance to the garage of the sorting center and then directed to a free space. Hence, any delay of transport cars can be detected in advance and a back-up plan can be made available. The number of baskets of letters required also benefits from better management. This centralization of information also makes it possible to prevent the volume of mail to be processed, such as during holiday periods, and consequently to provide for the necessary resources. Finally, process planning can be programmed using AI. Therefore, optimization of human and technical resources is possible. Communication within the organization between the different hierarchical levels and the different units is facilitated.

New technologies are revolutionizing the postal sector by offering operators the ability to develop innovative services. Thus, in some automated centers, an optical character recognition image and fingerprint digitized, it constitutes a unique identity called biometric technology. Finland’s national mail carrier Posti has announced going to implemented biometric identification systems called SisuID. This innovation is based on selfie or voice biometrics, reinforces payment security, while facilitating and simplifying customer use. The method allows for people can receive packages on behalf of the owner as well as make remote payments easier. (Burt, 2019).

It improves the reliability and management of mail and customer related information. For example, imagine that a person has registered his / her profile in a database of the post office. Thanks to the courier's unique identity, the Post Office has information about the items the customer has sent or received, so it is possible

to invoice accordingly at the end of the month. Another example of AI use in postal services is the direct delivery of items to the recipient's new address when the receiver informs a change of residence in their profile.

3.2 AI in distribution centers

Gone are the days when logistics consisted of moving loads by robotics arms. But buying a few machines is not enough to have an automated warehouse. Unlike mechanization, AI in distribution centers is a notion that involves a high dose of data analysis and information processing algorithms called warehouse intelligence. Postal couriers are increasingly automating their warehouse operations by use warehouse management system (WMS), warehouse control system (WCS) and warehouse execution system (WES). According to ABI Research press release 2019, more than 4 million commercial robots will be installed in more than 50,000 warehouses worldwide by 2025, compare to 4,000 in 2018. In 70% of cases, robotics would allow an improvement of more than 10% in terms of productivity, efficiency and capacity. The significant increase in rates will be fueled driven by the continued need for flexible and efficient automation of complete same-day delivery has become the norm (Britt, n.d, 3). Small mobile robots bringing shelves or bins of articles to an order picking station, robotic arms for palletizing or depalletizing, inventory drones crisscrossing the aisles of shelves, exoskeleton-type frames for handling assistance, small robots assistance with co-packing, connected glasses or augmented reality for picking by vision, connected gloves for scanning parcels. These new innovative objects or systems, often highly automated, have been taking over warehouses for two or three years and are in the process of gradually reshaping all logistics processes, from product reception to shipment, including storage, order preparation and custom packaging. Flexible, easy to set up and much less expensive than large, rigid, integrated automation and mechanization systems, they gradually enter warehouse processes to fulfill specific tasks or functions. For a warehouse, the concepts of logistics automation and intelligent consist of the following elements (see Appendix 3). Fixed equipment: automatic storage systems (stacker cranes), automatic conveyors, robots and sorting systems. Mobile equipment: Automated

guided vehicle (AGVs), forklifts, combination trucks, omnidirectional trucks, robots. And mobile technology: voice recognition, barcodes and radio frequency to transmit instructions to mobile or on-board terminals in order to guide operators in the warehouse; Management software: warehouse, stock and supply.

Implemented AI in distribution centers can enhance the quality of logistics process and has the ability to dramatically increase human capabilities. The potential of AI was decreasing delivery times: customer satisfaction, reduction in stocks. Reducing in logistics costs: increased productivity, optimization of logistics tools, improved responsiveness, improved surface area. It also improving of product monitoring: traceability, locating, control flow and minimizing work accidents, improving work environment. (Kuprenko, 2019)

3.3 AI in sorting letters and parcels

In recent years, the decline in mail has again amplified: the volume of letters to be distributed from 18 billion in 2008 to just over 9 billion in 2018 and could drop, if the trend continues, to 5 billion in 2025 (La Poste, 2017). In addition, in 2018, the service's account universal postal, which lists the income and expenses of this public service, was for the first time in deficit of € 365 million. (UPU, 2019). Added to this major challenge is the need for the postal operator to achieve its digital transformation and respond to the strong growth of e-commerce in a context of increased competition.

Today's mail sorting technologies include enhanced optical character recognition (OCR). This allows the machine to classify letters was printed out as well as handwriting to understand addresses. For example, the sorting technology currently used by Deutsche post offices, made by Siemens can read 90% of addresses written by hand. (Siemens Postal, Parcel & Airport Logistics, 2). The biggest challenge with sorters is that they have to determine the destination address according to the postal code correctly. From there, it can reduce the load of time, effort and money. Unusually shaped letters cause great problems for sorting technology. And as the

volume of traditional mail is expected to decline and the share of direct mail such as small parcels is forecast to increase, the proportion of items that are harder to sort will also increase. As a result, postal operators are upgrading their sorting equipment to be able to handle all sorts of different commodities. Nevertheless, not all mail can be automatically sorted, and all postal operators still have to use human resources for manual sorting.

For instance, UPS hub in Cologne Germany was implemented the Siemens parcel sorting System, capable of sorting up to 19,000 items in an hour with measuring of conveyor system approximate 40 km to optimize the supply chain. Swiss Post, Australia Post, PostNL and Deutsche Post AG are using letter and flats sorting systems, total processing more than 176 billion letters are handled annually. They also hope to reduce their costs by million euro per year. (Siemens Logistics)

3.4 AI in last mile delivery

In chapter 2.2 and 2.3, AI in distribution centers and sorting centers have been analyzed. The robot not only works in the warehouse, but also works on the street. This autonomous delivery robot will automate the last mile delivery and delivery of packages from the couriers to the customers. With the rise of e-commerce, distance delivery has exploded in recent years. Logistics circuits are more and more complex and pressure is raging on delivery costs. According to the new demand of consumers who want quality of service, flexibility in delivery schedules at the lowest prices, last-mile delivery creates a very competitive market, becoming a priority than ever before of all parties of the logistics and trade sector. In 2025, in McKinsey report predicts: "A world in which autonomous vehicles will deliver 80% of packages"; self-driving trucks will deliver a majority of packages by road; drones being more profitable in rural areas and bicycle couriers in dense urban areas for instant delivery. The remaining 20% (mainly business to business) will still be delivered by the traditional model: warehouses and rounds of delivery drivers. (Joerss et al., 2016). As can be seen in figure 5, last-mile delivery represents around 41 percent – or even more – of the supply chain costs.

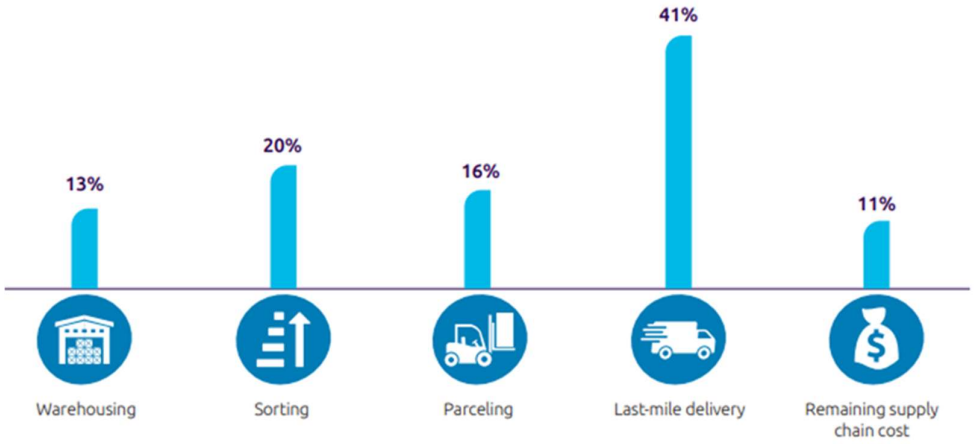


Figure 5. Cost Driver in the Supply Chain (Capgemini, 2019)

In the digital age, consumption habits have greatly evolved and created a need for almost immediate satisfaction among consumers. So, under normal circumstances, customers expect the products they want to always be available and delivered in time. According to a study conducted by Opinion Way, delivery time is one of the most important factors in the eyes of consumers. In addition, 79% of customers want real-time tracking of their package. This percentage is not surprising when you read that 62% of respondents say they have encountered a delivery, logistics or product problem in recent months. Accenture also made a survey about cuonsumer demand as can be seen in figure 6. Such expectations are very difficult for sellers to meet. This is why supply chain couriers must give 100% to guarantee fast and reliable delivery. Fortunately, customers can rely on the AI technology in last-mile to facilitate their work and keep track of goods throughout their journey to ensure optimum availability and timely delivery. Indeed, it can help improve the visibility and maximize the efficiency of the supply chain, from the warehouse to the final destination. (Buhler, 2019)

Figure 6. Consumer Demand Survey (Accenture)

Robotics was designed to offer “last mile” delivery solutions to businesses and communities. Each robot is programmed to automatically move through pedestrian areas and delivery from the pick-up point (kiosks, stores) to the delivery point (the customer's home). Information about delivery robots can be seen in appendix 4.

Parcels are delivered in specially designed letterboxes compatible with the robot, which the robot can open itself when arrive to destination. These boxes are only accessible to the recipient of the delivery. Efficient management of last mile logistics reduces the number of kilometers traveled, the time spent on the roads and traffic jams. (Capgemini, 2019)

Self-service lockers help customers pick up the parcels easier. It will avoid the case of delivery that customers do not have convenient time to receive, leading to delivery failures and re-deliveries and of course, it will take a lot of effort, time and money. (Joerss et al., 2016)

4 Implementation of AI in postal and parcel industry

4.1 AI technology in warehousing operations

Approximately 80 percent of warehouses are still manually run by people with little or no automation assistance. (St. Onge Company internal survey of customers). Since the advent of automation and robotics, this figure can be modified to make work

inside warehouses even easier. Robots may perform tasks that are risky, tedious or repetitive, allowing people to focus on things that required creative thing and less manual. (Autor, Levy & Murnane, 2003)

As believed by Tim Eick. “Artificial intelligence makes the warehouse of the future more dynamic, more agile, and more responsive.” (Eick, 2019). It is like a breakthrough and a leap forward for process optimization based on development of intelligent machine systems.

4.1.1 Barcode

Millions of letters and parcels are shipped by postal companies each year. Hence, it takes a convenient technology to optimize the time, effort, and money to control and track them. And barcodes appear to solve this problem. Bar codes use various codification or symbolism protocols, which differ depending on the constraints of use or standardization.

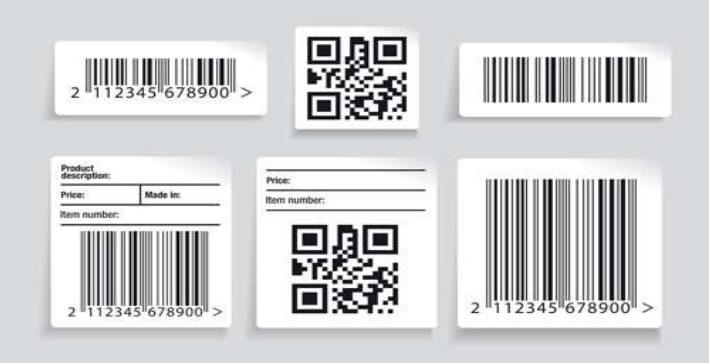


Figure 7. Type of barcodes (Hiroko, Keng, & Douglas, 2010)

Here are the two most used types of barcodes: One-dimensional or linear bar codes: which are the codes represented by a series of parallel lines of variable thickness with a one-dimensional reading. And two-dimensional bar codes: that are using a variety of symbols (rectangles, dots, hexagons and other geometric shapes). This matrix form allows more information to be recorded. (Hiroko, Keng, & Douglas, 2010, 18)

Barcodes can be considered as identity cards of packages. Previously, when there was no barcode, one had to manually enter information of the parcels such as sender, receiver, address, size, and weight to classify. In the presence of bar codes, postal units only need a barcode reader connected to the warehouse management system to easily classify sorting and delivering. (Hiroko et al., 2010, 140)

4.1.2 Radio Frequency Identification (FRID)

Nowadays, the identification and tracking of objects is developing more and more. Barcoding is a pioneering technology in the field of identification. However, it cannot store the amount of data. This is why RFID tags have developed. It is a technique that allows objects and people to be identified from a distance. The chip communicates through its antenna with the reader which transmits the information collected to a computer where it is recorded in a database. Conversely, the computer can store information in the chip through the reader, which also functions as a transmitter. Microscopic electronic chips with an antenna, they can be placed on labels.

RFID systems most often use low frequency (125-135 kHz), high-frequency (13.56 MHz), ultra-high frequency (433 MHz or 860-960 MHz according to the standards in force in the countries) and more rarely microwave (2.4 GHz). Figure 8 below are presented RFID frequency charateristics (Chawla, & Dong, 2007, 15)

Frequency range	< 135 KHz [LF]	13.56 MHz [HF]	860–960 MHz [UHF]	2.45GHz [Microwave]
Relevant standards	• ISO 11784 & 11785 • ISO/IEC 18000-2 • ISO 14223-1	• ISO/IEC 18000-3 • EPC class-1 • ISO 15693 • ISO 14443 (A/B)	• ISO/IEC 18000-6 • EPC class-0, class-1	• ISO/IEC 18000-4
Typical read range	<0.5 m	~1 m	~4–5 m	~1 m
Tag type	Passive-inductive coupling	Passive-inductive coupling	Passive or active	Passive or Active
Typical applications	Access control, animal tagging, vehicle immobilizer	Smart cards, access control, payment ID, item-level tagging, baggage control, biometrics, libraries, transport, apparel	Supply chain pallet- and box-level tagging, baggage handling, electronic toll collection	Electronic toll collection, cold chain management, environment monitoring
Multiple tag ead rate	Slower → Faster			
Ability to read near metal or wet surfaces	Better → Worse			
Passive tag size	Larger → Smaller			

Figure 8. RFID frequency charateristics (Chawla, & Dong)

Conceptually, RFID and bar coding are quite similar, both are intended to provide rapid and weak identification of items. The main difference between these two technologies is that bar coding is read with an optical laser and the RFID reader scans or interrogates a tag using radio frequency signals. Unlike the barcode reading system, RFID does not require a straight line of sight for readers to properly align these and adequately capture the data stored in labels. RFID allows readers can read the labels from long distance enough. In addition, a RFID can contain more data (up to 64,000 characters) than a label with 1D bar codes (i.e. less than 30 characters).

According to Bob Berg, in DHL´s Express, it cost 18 cents per Generation 2 UHF tags. But with the shipment over 2 billions shipment each year, it will multiply the cost. (DHL, n.d)

Figure 9. DHL Smart Sensors RFID (DHL)

RFID improved the postal logistics processes, advanced shipping notices, enhanced tracing and tracking mails and parcels with greater convenience and accuracy. Thanks to these advantages, the RFID can speed up mails and parcels sorting but the price is really expensive than barcodes.

4.1.3 Robotics

Recent developments in the robotics sector could become a game changer for the logistics industry. Robots can now recognize, select, manipulate and place a variety of objects in a variety of environments. The technologies we develop are proven to be critical to overcoming the challenge, and we hope they will allow further advances

in logistics and possibly adapt the demand of other industrial applications, thereby promoting productivity, reliability and profitability. (DHL, 2016)

The advantage of this solution is that in addition to increasing productivity (a robot does not, for example, eat, need breaks or go on strike) and precision, it will above all preserve the condition of the packages, because the robot uses a simple hoist and deposit mechanism rather than having to throw away the package in a careless manner, unfortunately common practice in the sector (DHL 2016). There are many type of robots in contribution centers with different functions such as follow the worker around warehouse, shelf-climbing, transport carts contain mails and small parcels or lift racks and bring them to the postman. They can carried the objects with weight from 22kg up to full racks 4535kg. For example, the shelf-climbing robot called Skypods running at Amazon can climb shelf to collect orders. Skypods come and go autonomously to look for products on racks up to ten meters high. Thanks to them, Amazon can store five times more on shelves and the gain in productivity over production time is multiplied by 4. It can process 400 parcels per hour and can carry upto 30kg at a time with speed of 16km/h. Other warehouse robots move whole shelves, Skypod climb the shelves instead. That’s what make them so fast. They use laser to navigate to move around the facility and stop them from colliding with each other. These robots charge hourly so they can opearte 24/7 (Pickering, 2017). Some warehouse robots information and appearance images were presented in appendix 5.

Order picking is the most important task in logistics. This is where the "goods to man" mode are quickly deployed, where the operator chooses the product he needs from boxes delivered to him. The "goods to robot" mode is entirely possible, provided the machine can perform picking. Thanks to its complex vision system and artificial intelligence software, its articulated arm is capable to catch a parcel in the box without learning.

Amazon has 45,000 Kiva robots in its various warehouses. These are robots that move the shelves towards the operators. These autonomous robots circulate on the floor, covered with QR codes, which allow them to identify their position to transport

the shelves containing the articles to the order pickers. Each robot can carry up to 500 kg and has an autonomy of 4 to 5 hours for 5 minutes of charging. Due to this, Amazone has reduced human labor in the warehouse by 70%. (Amazon)

Figure 10. Kiva robots at Amazon warehouse (Amazon)

4.1.4 Computer vision and sensors

One of the most powerful and engaging types of artificial intelligence is the vision sensor system. This is a field of computer science that focuses on the reconstruction of complex parts of the human visual system, allowing computers to identify and process objects in images and videos in the same way as humans do. Computer vision can identify, track, measure, detect and classify objects. This automation makes it possible to increase performance and production rates, make production more reliable, improve product quality, ensure their traceability, and guarantee safety. (SICK Sensor Intelligence)

Many courier services today do not only calculate the price of their cargo according to the actual weight of an item to be transported but also according to volume or density. If the specific gravity or bulk exceeds the actual weight, shipping or freight charges are calculated on this basis.

This technology determinate the dimensions of a rectangular object for the calculation of volumes or for sorting. With adjustable tolerances dimension, weighing, scanning system, the sensor determines characteristics as a surface, size, roundness or compactness of a object. The process sorting system for parcels of different sizes. In fact, the packages arrive randomly on a conveyor. Depending on certain characteristics defined in advance, the package is oriented to the left or to the right. The physical equipment used in this process consists of a conveyor, two pneumatic cylinders, the vision system, the processor and the automaton. A storage location, a post office, a logistics or distribution center or a transport system always necessary to optimize the storage location. This detector works as a single threshold switch or provides size, orientation and position of objects to the WMS or ERP. It also provides quality parameters to detect damaged or deformed packages. (Bpost 2019)

Regardless of the orientation and the number of codes, the reader multicodes automatically decodes 1D and 2D codes. The new version also solves recognition tasks text (optical character recognition), eg. for product identification using designations or serial numbers. Information such as senders, receivers, postal code, priority class

4.2 AI technology in delivery

4.2.1 Autonomous Vehicles

Transport is a key element of the logistics chain, helping to combine seemingly unrelated components in the supply chain. Therefore, the transport system needs to be managed optimally. This means that all members of the supply chain must have an absolute vision and strong communication. The success of any supply chain can be judged through the transport management process. Statistically, logistics and transportation can account for up to 7-14% of sales, depending on the business.

According to a McKinsey report, around 5% of Amazon shipments occur on the same day and by 2025 that figure is expected to rise to 15%. To meet these high demands for fast and free delivery, automating the delivery process is the answer. AI makes

autonomous vehicles safer by being able to navigate complex scenarios and traffic. With a lot of variables to take into account, there is a lot of machine learning that will come into play. (Joerss, Klink, Mann, Neuhaus, & Schröder, 2016)

An autonomous car is equipped with a lot of sensors to be able to locate itself in space. These sensors can be LIDAR lasers, radars, ultrasound or cameras. They allow the autonomous car to model its environment in 3D and identify the elements that make it up (buildings, vehicles, pedestrians, signage, road markings) in order to guide itself while respecting traffic rules and avoiding obstacles. (see figure 11)

All this information as well as others (traffic, GPS,) can be processed by artificial intelligence to define the driving situation instantly (Ex: speed limit sign which goes from 110 km/h to 90 km/h). Once the situation is defined, system decides on the maneuvers to be carried out. (Joerss et al., 2016)

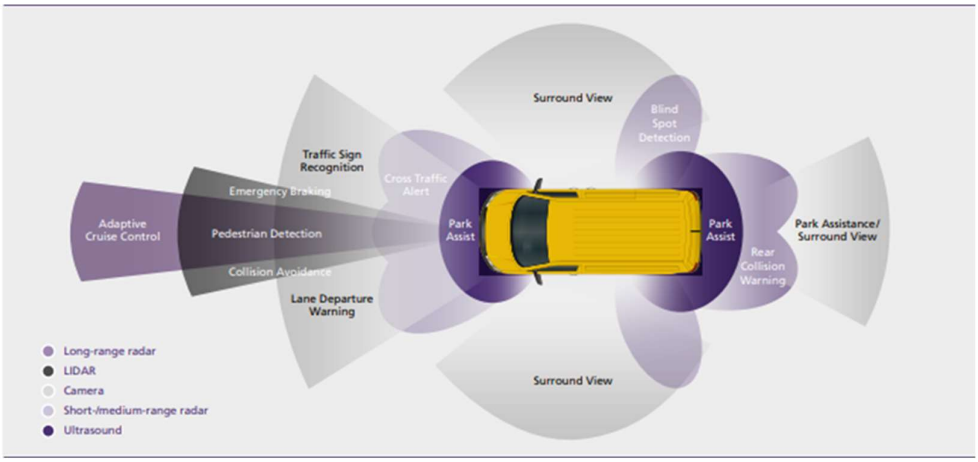


Figure 11. Sensing technologies in autonomous vehicles

As in other fields, AI will make it possible to meet the challenge of complexity (exploitation of large volumes of data) by providing more reliable indicators to optimize capacities and requests. The level of driving automation is upgrade to appropriate to the circumstances from 1 to 5. (No automation, driver assistance, partial automation, conditional automation, high automation and full automation).

A driver cannot drive more than 9 hours a day and must take a rest times at appropriate places. Autonomous trucks could reduce carrier costs by 30% by 2030, according to a PwC study. (PwC 2016)

Labor costs in this industry will continued to drop with the use of AI. The issue of long hours of driving and stopping for a break will no longer be an issue with fully automated fleets. Beyond simple labor costs, safety and traffic accidents will be greatly affected by AI. Some smart trucks can predict crashes by detecting health issues like heart attack from people in the vehicle. (PwC 2016)

Automated Guided Vehicle (AGV) technology helps reduce operating costs and achieve good productivity in a warehouse while ensuring optimal planning of transport and handling operations. Consequently, the risk of injury is limited, the manual transfer of products is eliminated and the punctuality of deliveries and the preservation of the environment of the development areas are guaranteed.

4.2.2 Drones/unmanned aerial vehicles (UAVs)

Using drones in the distribution centers to track parcels by scan barcodes take many advantages. Improved safety when avoid employee working at height, higher quality when 100% of pallettes are scanned and photographed or read RFID tags while precisely identifying the exact location of each item, it improves the location ofz stocks and reduces risk of lost parcels. And of course better service, the goal here is trying to shorten inventory time in order to reduced the number of potential shipping disruption. Drone can records the barcode of pallets by location in just 15 seconds compared to 2 minutes in manual mode. In addition to the operated drones in the warehouse, it is also applied outdoors to transport parcels as last-mile delivery solution. How to reach customers in remote areas more efficiently? The postal service solvled this issues by using drone to deliveried to areas that are difficult to access (mountain, islands, isolated rural areas) and in urgency situation. This new delivery method also helps reduce road risk, relieve road congestion, reduce pollution and save time. A package can be sent directly to its destination, without

waiting for its turn in a delivery truck. A drone can make a delivery in the middle of a park, a path, or places inaccessible by a road. (Joerss et al., 2016)

When think of “drone”, we may imagine a small device with four propellers, which control with our phone or a remote control, the size of a shoebox. But the devices that will be used for deliveries are quite different. First of all, they will be much larger to allow the transport of parcels of several kilos and have better autonomy. For example, DHL drone can fly at 60 km/h up to 30 km distance; it has 8 propellers and can carry up to 5 kilos of cargo (figure 12). The parcelcopter model is even bigger. With a single propeller, looks like a helicopter can deliver up to 5 kilos at a distance of up to 180 km. It can land on small areas where donot have runways. It uses artificial intelligence and machine learning to navigate, in case unforeseen situations arise - collision detection not only flying obstacles (other drones, planes, birds) but also fixed ones (cables, branches, clotheslines) that might be in the way. And drones ruuning by electric, so would be more environmentally friendly than gasoline-powered options. (DHL 2017)

Figure 12. DHL Drone (DHL)

4.2.3 Smart lockers

Home delivery has a heavy impact on the logistics costs of the last leg: if the receiver is absent (which occurs in more than 20% of cases according to FEVAD), the shipper will have to make a new delivery again affecting to ecology (carbon dioxide emission during transport) and economics issues. Click and collect lockers is a solution. Thanks to the smart parcel locker system, residents no longer need to be there to receive delivery in person and their parcel awaits them in a secure locker until it is collected. By means of a direct selection key, the delivery person chooses the recipient and the desired locker size. Smart lockers can be placed outside, in a covered place with a large number of visitors, or even directly in stores, markets or at a kiosk point. They are designed to operate 24/7 to provide convenient self-service access tailored to individual needs. (JLL 2019). With this system, receiving a package takes only seconds. The result is flexible in-store traffic, avoiding queues and delivering a satisfying customer experience, improving loyalty.

Figure 13. Posti Parcel Locker (Posti)

The smart locker helps prevent lost or stolen packages since they are immediately secured. They also avoid several travel costs since the packages do arrive at their

destination. Delivery man no longer need to come back to the same place until someone is present to pick up the package. Delivery man do not need to call anyone. They put each of the packages in one of the lockers. A text message and an email are sent to the co-owners with a code, notifying them that their package has been delivered. They go to the lockers, enter the code and pick up their package. It's very simple. The smart locker lowers delivery costs, eliminates the management of unnecessary packages and takes the frustration out of package recipients when late delivery.

5 Case of implemented of AI in the postal industry

The most typical type of AI using in the postal industry were presented in previous chapter 4. Real life cases from courier companies will be discussed in this chapter.

5.1 Case of AI technology in distribution centers and sorting

The use of robots is common in many warehouses and for some logistics centers there is a need to effectively keep track of inventory in many warehouses in various locations. The automation capabilities of AI increase the productivity achieved in a warehouse, which is simply not possible with a limited number of human employees. Implementing AI in the logistics process also helps eliminate human error. Obtaining AI technology for the warehouse can make very significant gains. It enables warehouse personnel and material handlers to improve their efficiency, productivity and accuracy; all of this translating into a significant reduction in checks, error rates and manual entries, but also significant progress towards "zero paper" and inventory discrepancy.

5.1.1 Belgium postal service Bpost and computer vision

According to a study by KPMG (2017), the total volume of parcels entering and leaving Belgium was around 140 million parcels in 2015.Three years later, Bpost distrib-

uted 14% more parcels. In Bierset alone, 5.8 million packages arrived from China last year. To meet demand and maintain the profitability of the system, couriers have no other choice but to innovate. The new Brussels X sorting center was officially inaugurated in 2017. With an area of 80,000 m², it is the largest center in the Benelux region and the second in Europe. The new sorting center is the cornerstone of the 'Vision 2020' strategy, launched by Bpost in 2015. It aims to improve its operational efficiency and is based on three pillars: centralization of indoor parcel sorting in the new center and the postman will spend most of their time outside serving the clients, organization of distribution from 60 ¨mail centers¨, and continuing to automate mail sorting in the five sorting centers. (Bpost, 2017)

In this new center, Bpost use latest technology regarding barcode reading, SCADA systems and automation. Bpost use of a very efficient and ultramodern sorting installation such as dynamic weighting with volume and image capture station, handwriting recognition system. To deliver more and more mail as quickly as possible, Bposte has several dozen sorting machines that use a handwriting recognition system. On each envelope, they can read and then identify the bar code, postal code as well as the name of the city and information of the recipient. d. The principle operating of OCR is very simple, firstly evelopes were detected by stationary camera when runing in conveyor belts. After that post code was extraction by OCR algorithms and sent to the database. Finally, these evelopes can be ready to classify other mail areas. According to Bpost, this solution that automatically read 94% addresses on mail, resulting in 30% more savings per mail item than manually entering data. Thanks to this state-of-the-art machine, which scans and sort packages, Bpost suddenly doubles its capacity to sorting to establish it at 300,000 packages per day. PSM is equipped with the latest technology available in the postal market. Some innovations, such as sensors reading can scan 360 degree and separate processing of larger packages with dimension of 120/70/60 cm. 2.4 million letters are also processed every day in the new Brussels X. (Bpost, 2017)

5.1.2 Portugal postal service and autonomous robots

Portugal postal service (CTT) implemented RoboSavvy's TugBot robots and Kuka industrial robotic arm at the parcel sorting handling center. The robots can indeed work on a 24 hour per day, free from the conditions of temperature, lighting or the total weight lifted during the day. The result is productivity, consistency and quality of performance of tasks superior to that of humans. At the same time, the use of robots brings better ergonomics of workstations and helps to fight against arduousness, musculoskeletal disorders and occupational accidents, by avoiding the operator to perform the most painful and repetitive tasks. The robots are intended to replace, supplement or assist certain positions to lower the logistics cost and increase efficiency while reducing human labor (United States Postal Service 2018). This is the case goods-to-person with robotic order picking solutions which are on the increase today. These systems are built around a fleet of collaborative mobile robots that automatically deliver the necessary products to the operator to prepare his orders without moving or leaving their picking station. This allows them to be more productive while having the ability to pick multiple orders at once more quickly. These devices are generally dedicated to e-commerce logistics.

Kuka robot would be able to visually identify the items that pass on the conveyor belt, to grab them with a robotic arm equipped with a pneumatic gripper and to place them on a preparation table for the employees. Its gripper system allows it to intelligently pick a wide variety of rigid or flexible packaging, correcting errors and unforeseen events without interrupting the flow of goods. They are equipped with mechanized arms that place the parcels or mails on containers. These machines are accompanied by advanced logistics software, able to analyze parcel parameters (weight, shape) and calculate the best way to stack the unit load on carts. After all of parcels are placed in the container, workers come to packaging and delivery. (Kuka, 2017). The main benefit of this type of machine is the speed they can achieve when picking. More reliability with automatic product scanning technology for serial number or order checking. They help you to prepare several orders as well as a large quantity of packages simultaneously, and in complete safety.

Figure 14. TugBot and Kuka robots at CTT sorting center (RoboSavvy, 2017)

10,000 packages sorted per hour by using small robots. Tugbot robots can carry 8 carts of up to 20 kg come to aid of the employees in sorting center. By scanning a bar code, they quickly determine where the package should be delivered. They are autonomous and are operational 24/7 because they recharge themselves when the battery is empty. Quickly and efficiently learn to manipulate new objectives. All robots use the same software, so when one learns, all improve. These robots operate completely autonomously. In the event of obstacles (such as people, pallets or forklifts) blocking their route, they avoid them in complete safety, determining the best deviation. Productivity is then optimized. They also offer significant space savings since the width of the aisle between the racks is limited to the footprint of the robot, which is often small. This solution saves 30% of storage space, increases the productivity of order preparation by 400% compared to a conventional process and avoids the operator having to travel on average 15 km per day to collect products in the racks. The system uses a fleet of autonomous robots that optically follow adhesive strips placed on the floor to bring parts storage shelves to an order picking station. (MOV.AI 2019)

5.2 Case of AI technology in delivery

5.2.1 Starship autonomous robots in last-mile delivery

Amazon, Wal-Mart, Alibaba and even La Poste see the future in delivery drones. Google intends to launch its Project Wing in 2017 while the Darpa wants a delivery drone capable of self-destruction. In short, if we are to believe the media effervescence around this theme, the sky should soon be studded with flying vehicles responsible for delivering small parcels. However, we have a little trouble believing it, as the regulatory and technical obstacles and security issues seem numerous.

If the option of delivery drones is not necessarily, there may be a much simpler alternative. Why not small automated delivery trucks? Starship Technologies, a young European startup created by Ahti Heinla and Janus Friis, two of the founders of the Skype service. They have developed a small container mounted on six wheels, a microphone, a speaker, 9 cameras, a GPS, ultrasonic sensors and map software that can move completely independently within a radius of five kilometers from its starting point. The robot receives the order to pick up its order (up to 18 kg). It will deliver an order in thirty minutes maximum, all for a price that would be 10 to 15 times lower than what home delivery services offer. (Starship Technologies)

Figure 15. Starship autonomous robot (Starship Technologies)

In 2017, Swiss Post was used Starship robots for delivering parcels to customers for three months, and these autonomous robots did not cause any accident or problems. “Our vision revolves around three zeros: zero cost, zero waiting time and zero environmental impact. We want to do for local deliveries what Skype has done for telecommunications”. Starship Technologies press release.

To increase the degree of action of these robots, the Starship Technologies team is working with Mercedes on a robovan. In 2017, Estonia’s postal service Omniva pilot implemented this solution in the capital city - Tallinn and delivered total 1,166 parcels during testing. The vans can carried 8 robots and 54 packages. This one could drop several Starship in some different stops to increase the radius of action. They create the synergy of transportation technologies for local delivery. It allow for robot enter and exit autonomously (see figure 16). In the future, this collaboration will ensure quick on-demand cost efective delivery for customers. Although this solution is very promising it is also proportional to the operating cost for fully autonomous for both vans and robots. In order to reduce the basic transportation cost, it is necessary to have a sufficient number of people living in the area to use this service. (UPS 2018, 13)

Figure 16: RoboVan by Starship and Mercedes-Benz (Starship Technologies)

5.2.2 French postal service using drones to delivery parcels to remote areas

The last mile market is colossal. In France, this corresponds to 20% of traffic, 25% of CO2 emissions and 30% of the total cost of delivery. La Poste announces the establishment of the first regular commercial line for parcel deliveries by drone. It takes place in the Var (South East France). The drone is operated by DPD Group, the international parcel delivery network of GeoPost, a subsidiary of La Poste. The drone is launched from a specially equipped truck. Once at destination, it deposits his package in a secure receiving terminal, then returns to the place of departure. According to DDP, drones has already operated a weekly 15 km commercial line between Saint-Maximin-La-Sainte-Baume and Pourrières (Var). Since December 2016., almost 190 flights have been carried out, with a success rate of 95% (bad weather conditions having forced to cancel the remaining 5%). (La Poste, 2019)

Figure 17: La Poste Drone (La Poste, 2019)

According to La Poste, the drone developed in association with the French company Atechsys is equipped with solar panels so that its battery does not run out of electricity in mid-flight. “It does not emit CO2, it protected natural environment”, emphasizes La Poste. Fully autonomous, it does not need any human intervention to land, drone drop the package and leave. The post office drone offers a range of up to

15 km at the speed 30km/h, or about 45 minutes of flight and can carry packages weighing up to 2 kg. (La Poste, 2019).

After a first regular drone delivery line set up in 2016, La Poste did it again in 2019, this time in the mountainous area on the outskirts of Grenoble. The delivery between the town of Fontanil-Cornillon (in the valley), in Isère, and the village of Mont-Saint-Martin (highland). The two locations are actually not very far from each other, barely 3 km as the crow flies, except the truck ride from one to the other is 20 km across winding mountain roads. However, these journeys can be dangerous and impractical, especially in winter. The drone takes 8 minutes roundtrip compare to delivery person has to travel about 30 minutes round trip (See figure 18). (La Poste, 2019)

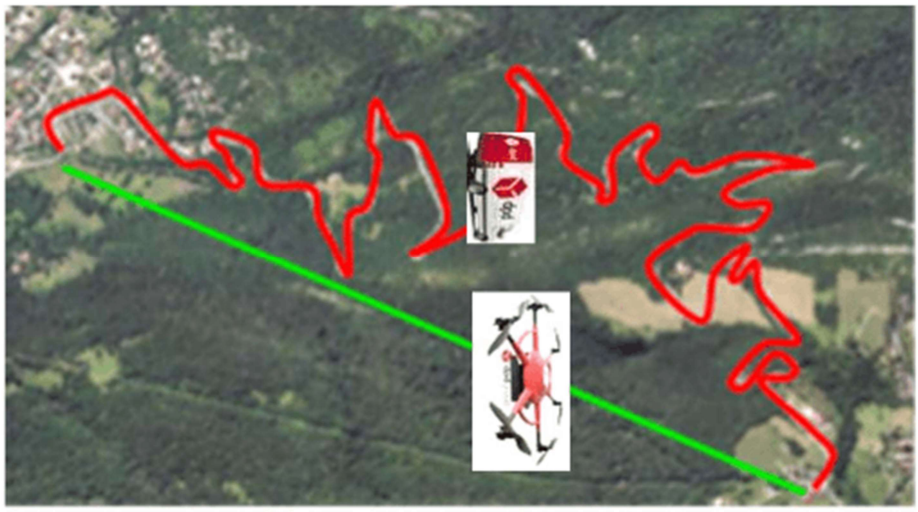


Figure 18: The comparision between delivery by truck (red line) and delivery by drone (green line) (La Poste, 2019)

In a press release, La Poste confirms the interest of this technology in mountainous areas: "For the delivery person, in addition to saving time, it is a reduction in road risk on roads which are sometimes impractical in the mountains, especially during winter. For the customer, it is the guarantee of receiving his parcel even when the

road is made impassable by precipitation. Finally, the propulsion of the drone being electric, it does not emit CO2 ".

For La Poste, it is " a new way of responding to the problem of the last mile, in particular to access areas that are difficult to access ", such as islands or in the mountains. (La Poste, 2019). Eventhough delivery by drone in the offers many advantages compared to the truck, howerver, they are not intended to distribute packages by drone in urban areas. Because there are many obstacles like trees, tall buildings and it is a bit difficult without government approval. They consider the drone to be useful for delivering hard-to-reach areas, in the mountains or in rural areas where the long car journey.

6 Challenges of AI adoption in postal operation

6.1 Impact of AI in labor market

Beyond worrying about technological advances and when a robot can finally get rid of a tedious task, this problem affects one of the most fundamental pillars of current society: employment and the market work. The automotive sector was the first, in the 1960s, to replace its workers in the most arduous jobs, but above all to increase its productivity. As a result, handling costs which, today, would be reduced by 20 to 40%, according to the research firm Roland Berger (Berger, 2017). Hence similar controversy also erupted in the postal industry over whether robots are the enemy of humans? On the one hand, those who claim that robotics creates new professions, on the other, the most pessimistic, convinced that robots will replace humans.

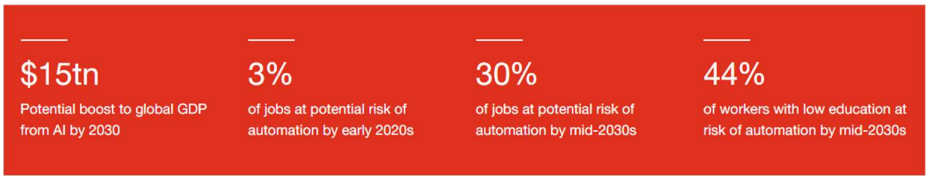


Figure 19. Potential impact of automation in labor market and economic issues (PwC, 2018)

A recent report by PwC estimates that depending on the level of development of each country, advances in automation will force 3-30% of workers worldwide to change jobs or need to upgrade their skills by 2030 (figure 19). Currently, about 10% of all jobs in Europe have disappeared since 1990 during the first wave of technological change based on repetitive work. Today, AI is able to repeat the same tasks over and over again, 7 days a week, 24 hours a day without errors. Accordingly, the low-class workers are the most affected by technology, in particular the less qualified professions which include repetitive tasks that can be easily automated, such as handling, packing, maintenance agents, operators. Thereby creating a widening gap between the rich and the poor.

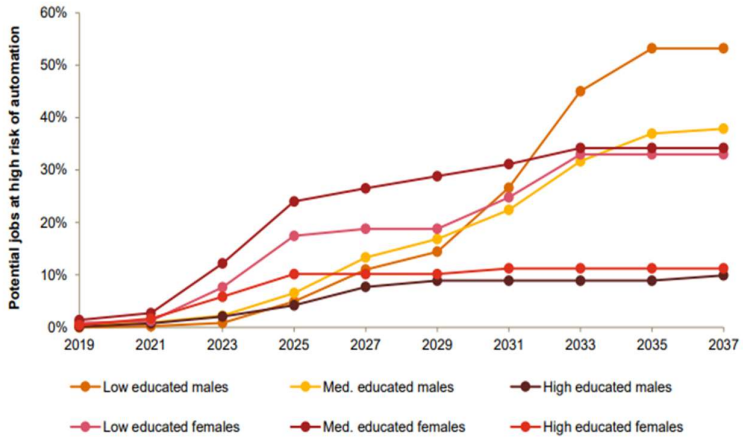


Figure 20. Impact of job automation by gender and education level (PwC, 2018)

As can be seen in figure 20, low educated males could face a highest risk of almost 60% by the 2037s, while low educated females can face 30% risk of automation. Medium educated males and high educated males face a roughly equivalent risk 30%-35%, while medium educated females and high educated females only face a lowest risk with 10%. The effect of AI on men is greater than that of women in the long run.

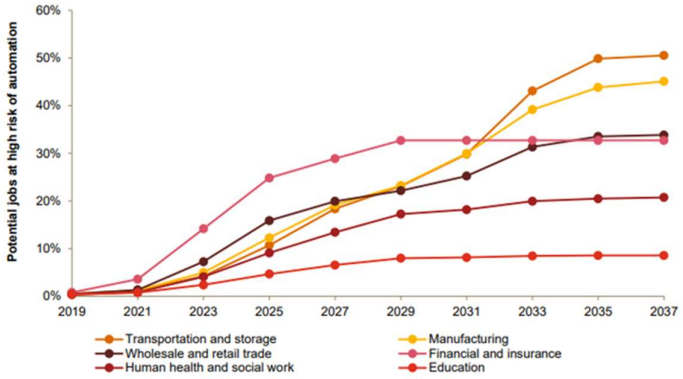


Figure 21. Impact of job automation on industry categories (PwC, 2018)

PwC sees that robots will replace some jobs, especially in areas such as transport or manufacturing. Accordingly, two sectors have the highest share of existing jobs that probably be machine-controlled by the 2030s are transportation & storage and manufacturing. AI are estimated to take over 52% of transport jobs and 45% of manufacturing jobs. (PwC, 2018, 18)

Like every industrial revolution, the advent of artificial intelligence will eventually be accompanied by the appearance of new professions. In other areas, more new jobs created by AI, to optimize the balance. As stated in PwC's prediction, jobs in many sectors are replaced by AI, while new jobs will appear. (PwC, 2018, 21).

On the front line, engineers and technicians who will work directly in the field of artificial intelligence. An artificial intelligence is built and perfected with large volumes of data: this is machine learning. This is one of the reasons for the boom in Data and related professions (such as data analysts, data engineers, data scientists) (PwC, 2018). As AI is used more in the workplace, new jobs will become necessary to monitor and coordinate machines and robots. In the opinion of the US tech billionaire Elon Musk, in the future, pickup trucks can drive themselves. Although trucks no longer need individual drivers, they will still need drivers of the entire fleet. According to Musk, this would be a more attractive working position than driving a truck.

But it is impossible to say precisely what types of professions will be created with the rise of AI. However, one thing is certain: there will be a lot of novelty and new career opportunities. Based on a study conducted by World Economic Forum, 85% of the professions of 2030 do not exist today. (WEF 2016, 3)

As claimed by PwC (2018, 31), employees from the UK, the US, Germany, India, and China are willing to learn new skills to maintain their job again the development of AI. In the same survey, 56% thinks government need to make ethics policy about this technology trend to deal with unemployment driven by AI. When a job is impacted, it is essential for companies to look for alternatives: training, requalification, for support the affected employee, whatever the level of education or skills. The application of modern technology to the production line is not a stepping-stone to gradually replace workers in the warehouse, but only to minimize human-related manufacturing errors that make the high product quality and stable. Because human is the key factor, there are stages robot that cannot replace humans. Each worker on the factory line is trained to become an independent quality supervisor, the person who performs the following stage must check the quality of the previous person.

6.2 Impact of AI in economic issues

E-commerce presents a huge opportunity for postal services as consumers become more and more comfortable ordering online. Postal, with a nationwide network and long experience in delivery, has become a reliable partner for e-commerce business. It can be said that postage has a huge demand when it catches on digital transformation technology. (Capgemini 2017)

The economic dimension also plays a role in the choice or not to adopt robotic solutions or applications integrating AI. The cost of robots and their financing appears to be one of the main constraints in the purchase of robots, in particular for SMEs. While robots have undeniable productivity advantages, they are robust, resistant to fatigue and tend to make fewer errors than human operators but use in automating a task or a series of tasks is not always a good option. Robots lack

versatility and the amortization of heavy investments is only justified if the market is large or the tasks to be automated are numerous and very repetitive.

The cost of a mobile robot is between 30,000 and 50,000 € per unit. This is the equivalent of an operator's salary costs for one year. As a result, its return on investment (ROI) can be as quick as a year or two, while an industrial robot, worth a few hundred thousand euros, will only be profitable after 3-5 years. The robot's profitability equation is based not only on its cost of purchase, but also on its usage speed, maintenance cost, and setup time. And acquiring robots can reduce operation and maintenance costs by around 30%, which can help pay off the initial investment. Logistics must manage the production process shorter than that of the industry. It is therefore necessary to adjust the settings more often, which can reduce its availability. Indeed, robots must be used all the time to make money. However, robots cannot quickly switch from one function to another, while humans are versatile. Also take into account the maintenance, the cost of which between 10% and 15% of its purchase value

The main benefits of Artificial Intelligence have already been presented in numerous press articles. McKinsey report estimates the creation of value with AI between 2,850 and 4,730 billion euros per year and across the world. McKinsey also believed that artificial intelligence could lead to global GDP growth of 1.2% per year until 2030. But the cabinet also notes that there are still some sticking points. Customers increasingly want more value for each product or service they use. Experience technology is an exciting thing people discover to enjoy the maximum benefits of each product. Demand for e-commerce is a worldwide trend. Buying and selling online is becoming more and more popular, becoming the favorite of the majority of people. Sales businesses quickly meet that demand to increase retail volume and gain profits. The last thing to do is to serve requests that are broadcast on the information system and give the customer a desired result. (Bughin, Chui, Manyika, & Seong, 2018)

Boston Consulting Group firm estimates that the cost of an industrial robot will, on average, drop by 22% by 2025 (103,000 dollars) compare to 2005 (182,000 dollars).

At the same time, their efficiency will increase by 5% per year. And if human employment may be threatened, the competitiveness of companies will gain: robotization will drop the average cost of global labor by 16% (BCG 2015)

According to PWC's “Sizing the prize” study, global GDP could grow 14% by 2030 thanks to AI. The productivity gains generated by artificial intelligence technologies should represent half of the expected economic benefits. All industries and businesses will be impacted by AI in one or another way, the postal industry is no exception. The performance of the entire warehouse can reach a new level. The integration of AI, however, requires high expenses to improve the IT system: with periods of development and programming, which many companies do not (yet) or cannot afford. For the integration of AI to go smoothly, changes in project management and investments in new technologies are necessary. It should be checked whether it is profitable or not in each case. Small and medium-sized businesses have every incentive to use external service providers. They can help them get the most out of AI (as with the use of cloud computing technologies) while taking into account their human and financial resources. (PwC 2017)

The number of robots used in global industry has reached a record high (800,772 at the end of 2003) as the price of these machines drops while the cost of labor increases, claimed by Economic Commission of the United Nations for Europe (UNECE). Robot price have fallen in comparison with labor compensation were presented in figure 22 below.

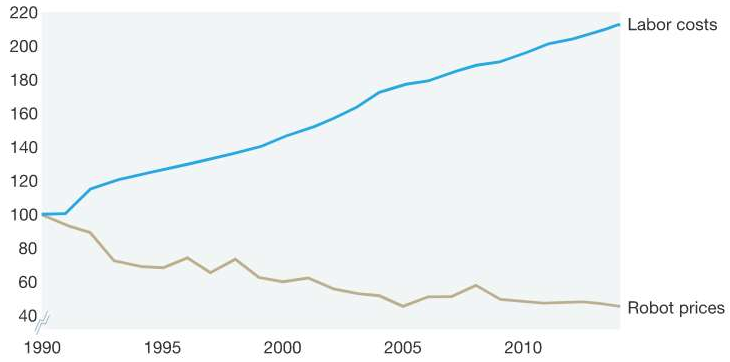


Figure 22: Labor cost compare robot prices (1990=100%)

Therefore, automation must be analyzed on a case-by-case basis and its implementation results from a flexible economic calculation. From this point of view, the gradual proliferation of AI and robotics technologies could lower costs and democratize their use, as seen in all technologies entering an evolutionary and development phase.

7 Discussion

7.1 Research results

How AI is becoming the game changer in postal industry?

The main conclusion that can be drawn is that all delivery companies are generally aware that AI technology is a way of innovating their industry to cope with the growing market. New technologies are turning traditional postage providing basic services into a commercial enterprise that fulfills customers' different expectations and introduces them into the innovation process. It is the harmonious combination between man and machine that contributes to creating quality products in the best conditions, saving time and labor when dealing with a huge amount of mails and parcels. In addition, these findings provide additional information about postal operators are using AI to automate the postal mail process with the aim of reducing costs. They also use AI to develop new, reliable, interactive services with competitively prices. The postal industry also hopes to play a role in the development of the information society.

How the AI is applied in postal and parcel industry?

With the help of AI, the logistics industry will see its operating model evolve from reactive actions to a proactive and predictive paradigm, which will bring a better understanding at attractive costs of back-office activities, operation and face-to-face with clients. AI technologies can, for example, use advanced image recognition to

track the status of shipments and assets, bring end-to-end autonomy to transport, or predict fluctuations in global shipping volumes before they occur. AI increases human capacities, but also eliminates repetitive or routine tasks, then making it possible to evolve the work of logistics staff towards work with greater added value.

Which postal and parcel companies are adopted AI technology?

With development of AI, postal companies will get the huge benefits when adopting this technology. As shown in chapter 5, Bpost with machine vision system, CTT with sorting autonomous robots, Swiss Post and Omniva with delivery robots or La Poste with drone which turned into an optimization leap in the process that made mail sorting and delivering faster and more efficient. AI technology helps postal service reduce manual processing, reduce human errors, cut down labor cost and make work environment more safety. Better services for customers will also bring loyal relations leading to increased profits.

How will AI change postal and parcel services in the future?

The ¨Goods to Man¨ promotes humanistic and non-humanoid robotization, robotization whose purpose is beyond simple technological prowess. Robotization gives the order picker a more strategic role in the supply chain. Employees become direct partners of the end customer by controlling stocks from their ergonomic stations, they work with more safety and less risk of error. The upgrading of their profession is made possible by the fact that tasks with lower added value are performed by robots. In addition, the order pickers are released from the obligation to walk 15km per day leading to fatigue and musculoskeletal risks. In short, it's them, the first beneficiaries of ¨Goods to Man¨. At the same time, the end consumer benefits from ever faster service, knowing that their purchasing history and receiving mails and parcels as soon as they can.

What are advantages of AI in logistics?

In the field of logistics, autonomous systems already take over customer relationship tasks. Robots, for example, manage logistics processes by applying optimization algorithms and furthermore allow rapid detection of risks within the supply chain based on the overall assessment of different factors. It is legitimate to think that AI will certainly change intralogistics processes towards a new, more flexible model. Thanks to automation and the numerous possibilities for digitization, the productivity of the warehouse will also increase significantly. AI technologies also increase picking and order picking performance, through more reliable processes and real-time adjustment of inventory levels. Incorporation of AI-controlled robots reduce preparation times and increase reliability.

What challenges do companies will take when implementing AI in operation?

Besides, the use of AI in the postal sector poses new challenges. In fact, the data indicate that only 26% of postal operators are satisfied with their capabilities in the field. Several factors could explain this finding. Firstly, the structure of incumbents is incompatible with the speed of AI innovation, which slows down their adaptation. Secondly, cooperation between technology providers and the postal industry is also lacking in the setting of common standards. Therefore, the absence of an international standard for RFID is an obstacle to the implementation of this technology in mail processing. Indeed, it leads to interoperability problems between the different terminals of different operators and the handling of international mails becomes difficult. Thirdly, SMEs may face financial difficulties in integrating AI technology, due to relatively low volumes of mail shipped. And finally, the concern of the challenges of applying AI is that it can threaten employees' jobs. Perhaps some professions will eventually disappear because AI in some areas do the job even better than a human, but it will not replace the expert. AI will rather be our assistant. It is high time today to talk about AI technology in a dispassionate and less anxiety-provoking way. No, the AI is not the systematic enemy of the worker. Yes, they are perhaps their best ally to improve their well-being and upgrade their job!

Through this research, the study was able to answer the research question which was: "How Artificial Intelligence can affect postal and parcel industry" based on the

theoretical and practical level. AI will improve delivery services, enhance customer experiences. By applying AI to core systems, companies can invest more in new business strategies to modernize and optimize processes. This can increase productivity and profitability more efficiently, while also giving employees time to improve skills and reshape their capabilities. This study will end with the limits to be taken into consideration as well as avenues for future research to enrich this area of study.

7.2 Future further research

In present, the research was conducted in at the early explosive and powerful stage of AI, some available data are limited to access because some concepts are new and limited to commercial operation. For example, unmanned aerial vehicle or self-driving cars is in its test phase in some special regions, therefore operating cost data is difficult to find. The primary data was collected and analyzed data from academic articles, videos, books, logistics journals, research studies, podcast and based on a comprehensive review of current postal industry internal publications and academic researches. The information come from accurate and reliable resources. All the data presented can be trust and used for reference to prepare for the inevitable future of AI technology.

In the future, when AI is implementing more widely and further studies can be research again with same method and questions. The more relevant future data is collected from the actual operation of self-driving vehicles, the results will be more detailed and reliable, then better view of the topic can be obtained. The study not only looks at the economic aspect of technology deployment, but also delves into the cost of implementation. Loss control of AI systems, safety and ethical issues or criminal uses of AI was not identified in this study, it could be an additional research aspect in the future.

References

Advani, V. 2020. *What is Artificial Intelligence? The Ultimate Guide to Learning AI*. Accessed on 17 May 2020. Retrieved from https://www.mygreatlearning.com/blog/what-is-artificial-intelligence/

Allas, T., Bughin, J., Chui, M., Dahlström, P., Hazan, E., Henke, N., Ramaswamy, S., & Trench, M. 2017. *Artificial intelligence the next digital frontier?*. Accessed on 15 May 2020. Retrieved from https://www.mckinsey.com/~/media/McKinsey/Industries/Advanced%20Electronics/Our%20Insights/How%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/MGI-Artificial-Intelligence-Discussion-paper.ashx

Autor, D., Murnane R. J., & Levy, F. 2003. *The Skill Content of Recent Technological Change: An Empirical Exploration.* Accessed on 2 October 2020. Retrieved from https://economics.mit.edu/files/11574

Aspers, P., & Corte, U. 2019. What is Qualitative in Qualitative Research. Qual Sociol 42, 139–160. Accessed on 2 May 2020. Retrieved from https://doi.org/10.1007/s11133-019-9413-7

BCG. 2015. *How Robots Will Redefine Competitiveness*. September 23, 2015. Accessed on 11 November 2020. Retrieved from https://www.bcg.com/publications/2015/lean-manufacturing-innovation-robots-redefine-competitiveness

BCG. 2015. *Industries and Economies Leading the Robotics Revolution*. Accessed on 11 November 2020. Retrieved from https://www.bcg.com/publications/2015/lean-manufacturing-innovation-industries-economies-leading-robotics-revolution?awsPersonalize=true&awsPersonalizeView=standaloneArticle

Bekker, A. 2019. *5 Types of AI to Propel Your Business*. Accessed on 4 December 2020. Retrieved from https://www.scnsoft.com/blog/artificial-intelligence-types

Berger, R. 2017. *Future of Work*. November 20, 2017. Accessed on 17 September 2020. Retrieved from https://www.rolandberger.com/en/Point-of-View/Future-of-Work.html

Bpost. 2017. *2017 Annual Report.* Accessed on 15 October 2020. Retrieved from https://corporate.bpost.be/~/media/Files/B/Bpost/year-in-review/en/bpost-annual-report-2017.pdf

Bughin, J., Chui, M., Manyika, J., & Seong, J. 2018. *Notes from the AI frontier: Modeling the impact of AI on the world economy*. Accessed on 1 November. Retrieved from https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-AI-frontier-modeling-the-impact-of-ai-on-the-world-economy

Buhler, B. 2019. *Accenture: The changing last mile*. Accessed on 17 August. Retrieved from https://www.accenture.com/us-en/insights/public-service/postal-research-last-mile

Burt, C. 2019. *Finnish postal service plans biometric authentication pilot with SisuID*. Accessed on 17 September 2020. Retrieved from https://www.biometricupdate.com/201912/finnish-postal-service-plans-biometric-authentication-pilot-with-sisuid

Britt, P. 2019. N.d. *How Growing E-Commerce Demand is Driving Growth in Mobile Robotics*. Accessed on 2 October 2020. Retrieved from https://www.roboticsbusinessreview.com/wp-content/uploads/2019/08/RBR-Whitepaper-GeekPlus-Final.pdf

Buchanan G. B. 2006. *A (Very) Brief History of Artificial Intelligence*. 53-59. AI Magazine. Accessed on 3 May. Retrieved from https://cse.sc.edu/~mgv/csce580f12/Buchanan2005.pdf

Capgemini. 2019. *The last-mile delivery challenge*. Accessed on 8 October 2020. Retrieved from https://www.capgemini.com/wp-content/uploads/2019/01/Report-Digital-%E2%80%93-Last-Mile-Delivery-Challenge1.pdf

Chawla, V., & Dong, S. H. 2007. *An Overview of Passive RFID*. Accessed on 9 July 2020. Retrieved from https://www.mics.ece.vt.edu/content/dam/mics_ece_vt_edu/Research/Publications/ByFaculty/Papers/Ha/07comm.pdf

Chen, F. 2017. *AI, Deep Learning, and Machine Learning: A Primer.* Accessed on 4 December 2020. Retrieved from https://a16z.com/2016/06/10/ai-deep-learning-machines/

Copeland, M. 2016. *What's the Difference Between Artificial Intelligence, Machine Learning and Deep Learning?* Accessed on 5 December 2020. Retrieved from https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

Copenhagen Economics. 2019. *Postal Service in the EU*. Accessed on 15 October 2020. Retrieved from https://www.europarl.europa.eu/RegData/etudes/STUD/2019/629201/IPOL_STU(2019)629201_EN.pdf

Davis, M. 2012. *Postal Operations: Achieve productivity gains with bar code scanning & mobile computing*. Accessed on 15 September 2020. Retrieved from https://country.honeywellaidc.com/CatalogDocuments/postal-industry-whitepaper.pdf

DHL Chips in on RFID. 2006. Page on the Light Reading website. Accessed on 9 July. Retrieved from https://www.lightreading.com/dhl-chips-in-on-rfid/d/d-id/624748

DHL. 2016. *Robotics in Logistics.* March 2016. Retrieved from https://www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_trendreport_robotics.pdf

DHL. 2019. *Logistics Trend Radar (2018/2019).* Accessed on 24 July 2020. Retrieved from https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/glo-core-trend-radar-widescreen.pdf

DHL. 2019. *Self-Driving Vehicles in Logistics*. Accessed on 20 July 2020. Retrieved from https://discover.dhl.com/content/dam/dhl/downloads/interim/full/dhl-self-driving-vehicles.pdf

Eick, T. 2019. *The learning warehouse – the next quantum leap thanks to artificial intelligence*. Accessed on 12 September 2020. Retrieved from https://www.swisslog.com/en-us/industry-40/artificial-intelligence-ai-machine-learning-warehouse

Egon, G., & Lincoln, Y. 1994. *Competing paradigms in qualitative research*. 105. Handbook of qualitative research, vol. 2, no 163-194.

Flasiński, M. 2016. *Introduction to Artificial Intelligence*. 3-5. 1st. ed., New York: Springer International Publishing

Fujitsu. 2017. *The World's First Level 3 Autonomous Driving Car Appears at Last: What are the Hottest AI/IoT Technologies for Automobiles?* October 23, 2017. Accessed on 10 October 2020. Retrieved from https://journal.jp.fujitsu.com/en/2017/10/23/01/

Gesing, B., Michelsen, D., & Peterson J. 2018. *Artificial Intelligence in Logistics*. Accessed on 15 May 2020. Retrieved from https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/glo-core-trend-report-artificial-intelligence.pdf

Harwood T, Maltby J, Mukaetova-Ladinska E. B. 2019. *Role of Artificial Intelligence (AI) Art in Care of Ageing Society: Focus on Dementia*. Accessed on 5 December 2020. Retrieved from doi:10.21926/obm.geriatr.1903062

Hinton, G., Bengio, Y., &Yann, L.C. 2015. *Deep Learning: Nature, vol. 521*, 436-444. Accessed on 5 December 2020. Retrieved from https://www.nature.com/articles/nature14539

Hiroko, K., Keng, T., & Douglas, C. 2010. *Barcodes for Mobile Devices*. 12-15. 1st. ed., New York: Cambridge University Press

How will AI impact the transportation industry? 2019. Page on the Becoming Human's website. Accessed on 1 October 2020. Retrieved from https://becominghuman.ai/how-will-ai-impact-the-transportation-industry-7d5e315f2799

IBA Global Employment Institute. 2017. *Artificial Intelligence and Robotics and Their Impact on the Workplace*. Accessed on 15 November. Retrieved from https://www.ibanet.org/Document/Default.aspx?DocumentUid=c06aa1a3-d355-4866-beda-9a3a8779ba6e

Kaplan, J. 2016. *Artificial Intelligence: What Everyone Needs to Know.* 27-60. 1st. ed., New York: Oxford University Press

Korus, S. 2019. *Industrial Robot Cost Declines Should Trigger Tipping Points in Demand*. Accessed on 5 November. Retrieved from https://ark-invest.com/analyst-research/industrial-robot-cost-declines/#fn-64055-1&_ga=2.84260761.1292512126.1604632201-1273707674.1603596034

Kuka industrial robotics medium payloads. 2017. Page on KUKA Roboter GmbH's website. Retrieved from https://www.ferob.fi/wp-content/uploads/KUKA_PB_MEDIUM_PAYLOADS_en.pdf

Kuprenko, V. 2019. *How AI Changes the Logistic Industry*. Accessed on June 2020. Retrieved from https://towardsdatascience.com/how-ai-changes-the-logistic-industry-3d55401778d

Joerss, M., Klink, C., Mann, F., Neuhaus, F., & Schröder, J. 2016. Parcel delivery: The future of last mile. September 2016. Accessed on 9 August 2020. Retrieved from https://www.mckinsey.com/~/media/mckinsey/industries/travel%20transport%20and%20logistics/our%20insights/how%20customer%20demands%20are%20reshaping%20last%20mile%20delivery/parcel_delivery_the_future_of_last_mile.ashx

JLL. 2019. *How can parcel lockers improve last-mile delivery?* Accessed on 3 October 2020. Retrieved from https://www.jll.fi/fi/trendit-ja-tutkimukset/kaupungit/how-can-parcel-lockers-improve-last-mile-delivery

La Poste. 2019. *DPD France launches a parcel delivery line using drones in Isère*. November 7, 2019. Accessed on 20 October. Retrieved from https://www.groupelaposte.com/en/article/dpd-france-launches-a-parcel-delivery-line-using-drones-in-isere

La Poste. 2017. *Annual Business Report 2016*. 23 February 2017. Accessed on 2 July 2020. Retrieved from https://le-groupe-laposte.cdn.prismic.io/le-groupe-laposte%2Fbbe59c1a-0e3e-4346-9043-13c3a5f43856_pr_2017_02_23.pdf

Leonardo parcel sorting system for Bpost national sorting center in Bruxelles. 2019. Leonardo Company's Youtube Channel. Retrieved from https://www.youtube.com/watch?v=Yb3rAloyTQY&ab_channel=LeonardoCompany

MOV.AI. 2019. *Autonomous Logistics Robots Controlled by MOV.AI's Operating System Are Making the Parcel Sorting Process of the Portugal Postal Services Scalable and Safer*. Accessed on 1 November 2020. Retrieved from https://www.prnewswire.com/news-releases/autonomous-logistics-robots-

controlled-by-movais-operating-system-are-making-the-parcel-sorting-process-of-the-portugal-postal-services-scalable-and-safer-300820232.html

Ng, A. 2019. *Andrew Ng Explains Enterprise AI Strategy*. Accessed on 4 December 2020. Retrieved from https://www.cxotalk.com/episode/andrew-ng-explains-enterprise-ai-strategy#_Toc28253908

Pickering, J. 2017. *This Amazon-style warehouse robot can climb massive shelving units to stack 400 parcels an hour*. Accessed on 29 July 2020. Retrieved from https://www.businessinsider.com/exotec-ai-shelf-climbing-robot-process-warehouse-orders-amazon-alibaba-2017-12

Postal Innovation Platform. 2017. *Technology is a game changer*. Accessed on 20 October 2020. Retrieved from https://cdn.website-edtor.net/66c04de9633342feb08aaf916f1d0199/files/uploaded/PI%2520Newsletter%25202017%252004.pdf

Postal Technology International. 2014. *2014 Annual Showcase*. UKIP Media & Events Ltd. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Consumer-Business/gx-cb-last-mile.pdf

PricewaterhouseCoopers. 2018. *Will robots really steal our jobs?* Accessed on 15 September 2020. Retrieved from https://www.pwc.co.uk/economic-services/assets/international-impact-of-automation-feb-2018.pdf

Petropoulos, G. 2018. *Work in the Digital Age*. 127. Rowman & Littlefield International Ltd. Accessed on 10 October 2020. Retrieved from https://policynetwork.org/wp-content/uploads/2018/06/Work-in-the-Digital-Age.pdf

Perez, J. A., Deligianni, F., Ravi, D., & Yang, G. Z. N.d. *Artificial Intelligence and Robotics.* Accessed on 11 May 2020. Retrieved from https://arxiv.org/ftp/arxiv/papers/1803/1803.10813.pdf

PwC. 2017. *Sizing the prize.* 2017. Accessed on 13 November 2020. Retrieved from https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf

PwC. 2018. *AI will create as many jobs as it displaces by boosting economic growth*. Jul 17, 2018. Accessed on 30 October 2020. Retrieved from https://www.pwc.co.uk/press-room/press-releases/AI-will-create-as-many-jobs-as-it-displaces-by-boosting-economic-growth.html

PwC. 2018. *Workforce of the future*. May 2018. Accessed on 15 September 2020. Retrieved from https://www.pwc.com/gx/en/services/people-organisation/workforce-of-the-future/workforce-of-the-future-the-competing-forces-shaping-2030-pwc.pdf

Schultebraucks, L. 2018. *A Short History of Artificial Intelligence*. Accessed on 15 April July 2020. Retrieved from https://lasseschultebraucks.com/ai/machine%20learning/2017/12/17/a-short-history-of-artificial-intelligence.html

SICK Sensor Intelligence. 2020. *Efficient solutions for Warehouse and Distribution*. 2020. Accessed on 2 November 2020. Retrieved from https://cdn.sick.com/media/docs/7/87/187/Industry_guide_Efficient_solutions_for_Warehouse_and_Distribution_en_IM0058187.PDF

Siemens Logistics. *References*. Accessed on 15 October 2020. Retrieved from https://www.siemens-logistics.com/en/references#parcel-logistics

Siemens. 2015. *Siemens: 50 years mail sorting automation for Deutsche Post*. Accessed on 15 October 2020. Retrieved from https://mailingsystemstechnology.com/article-1559-Siemens-50-years-mail-sorting-automation-for-Deutsche-Post.html

Smolensky, P. 1987. *Connectionist AI, symbolic AI, and the brain, Artificial Intelligence Review, vol. 1, no 2*. 95-109. Ed

Stake, R. 2008. *Qualitative case studies, Strategies of qualitative inquiry.* 119-149. Ed. California: Sage Publications.

Starship Technologies (2017). *Robotic Delivery Paving the Way for Efficient and Sustainable Delivery Supply Chain Management*. Accessed on 15 October 2020. Retrieved from https://cdn.website-editor.net/66c04de9633342feb08aaf916f1d0199/files/uploaded/PI%2520Newsletter%25202017%252004.pdf

Statista 2020. *Ecommerce in Europe*. Accessed on 30 July 2020. Retrieved from https://www.statista.com/outlook/243/102/ecommerce/europe?currency=eur

Symonds, D. 2017. *Bpost opens Europe's second largest parcel sorting center.* Accessed on 15 October 2020. Retrieved from https://www.parcelandpostaltechnologyinternational.com/news/parcels/bpost-opens-europe%C2%92s-second-largest-parcel-sorting-center.html

Robovan - Future Proof Local Delivery. Starship Technologies's Youtube Channel. Retrieved from https://www.youtube.com/watch?v=lzwz1UsxYdk&feature=emb_logo&ab_channel=StarshipTechnologies

Russel, S., & Norvig, P. 2016. Artificial intelligence: a modern approach. Ed. Malaysia: Pearson Education Limited.

Tilly, J. 2017. *Automation, robotics, and the factory of the future*. Accessed on 30 October. Retrieved from https://www.mckinsey.com/business-

functions/operations/our-insights/automation-robotics-and-the-factory-of-the-future

Thomas, M. 2019. *The Future of Artificial Intelligence.* June 8, 2019. Accessed on 15 May 2020. Retrieved from https://builtin.com/artificial-intelligence/artificial-intelligence-future

TUGBOT Automated Guided Vehicle. 2017. RoboSavvy's Youtube Channel Accessed on 29 September 2020. Retrieved from https://www.youtube.com/watch?v=e4rZODmsSxw&feature=emb_logo&ab_channel=RoboSavvy

Universal Postal Union UPU (2019). *The digital economy and digital postal activities – a global panorama.* Accessed on 29 September 2020. Retrieved from https://www.upu.int/UPU/media/upu/publications/Digital-economy-and-postal-digital-activities_EN.pdf

United States Postal Service. 2018. *Autonomous Mobile Robots and the Postal Service*. Accessed on 2 November 2020. Retrieved from https://www.oversight.gov/sites/default/files/oig-reports/RARC-WP-18-006.pdf

Wik-Consult. 2013. *Review of Postal Operator Efficiency*. November 2013. Accessed on 20 September 2020. Retrieved from https://www.ofcom.org.uk/__data/assets/pdf_file/0017/19313/wik.pdf

Wik-Consult. 2016. *Technology and change in postal services – impact on consumers.* Accessed on 22 September 2020. Retrieved from https://www.wik.org/fileadmin/Studien/2016/WIK-Consult_CitA_Impact_of_technology_full-report.pdf

World Economic Forum. 2016. *The Future of Job: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*. Accessed on 30 October 2020. Retrieved from http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

X

Appendices

Appendix 1: The table of resources to collect data for research

Objectives	Author	Publication Year	Title	Publication type	Research
Implementation	Ben Gesing, Steve J. Peterson, Dr. Dirk Michelsen	2018	Artificial Intelligence in Logistics	Report	Provided general picture of AI and analyse challenges and risks. This article also gives some examples of AI technology in other industries like retail, manufacturing, transportation. Inventory management using computer vision, autonomous vehicles or virtual assistant helps companies more efficacy in operating and enhance customer experience.
	Bpost	2017	2017 Annual Report	Report	This report determinate the dimensions of a rectangular object for the calculation of volumes or for sorting. With adjustable tolerances dimension, weighing, this detector works as a single threshold switch or provides size, orientation and position of objects to the WMS or ERP. It also provides quality parameters to detect damaged or deformed packages
	Dan Symonds	2017	Bpost opens Europe's second largest parcel sorting center	Blog post	Bpost use latest technology regarding barcode reading, SCADA systems and automation. Bpost use of a very efficient and ultramodern sorting instal-lation such as dynamic weighting with volume and image capture station, handwriting recognition system. Handwriting recognition system (opticalc recognition) can speed up the mail sorting process compare to manual. It also helps avoid human errors or require less human labor.
	DHL	2016	Robotics in Logistics	Report	This report presented many types of robots in contribution centres with different functions such as follow the worker around warehouse, shelf-climbing, transport carts contain mails and small parcels or lift racks and bring them to the postman.
	DHL	2019	Self-Driving Vehicles in Logistics	Report	Provided overview of self-driving vehicles technology and wide range of huge benefits. Advantage of autonomous vehicles is that a robot does not eat, does not need break, does not strike, then it will lead to increasing productivity.
			the factory of the future		answer. AI makes autonomous vehicles safer by being able to navigate complex scenarios and traffic. With a lot of variables to take into account, there is a lot of machine learning that will come into play.
	MOV.AI	2019	Autonomous Logistics Robots Controlled by MOV.AI's Operating System Are Making the Parcel Sorting Process of the Portugal Postal Services Scalable and Safer	Article	Implementing sorting and picking robots into Portugal postal warehouse. The result is productivity, consistency and quality of performance of tasks superior to that of humans. This solution saves 30% of storage space, increases the productivity of order preparation by 400% compared to a conventional process and avoids the operator having to travel on average 15 km per day to collect products in the racks.
	Starship Technologies	2017	Robotic Delivery Paving the Way for Efficient and Sustainable Delivery Supply Chain Management	Interview	Swiss Post and Estonian Post was used Starship robots for delivering parcels to customers. They also cooperate with Mercedes on a robovan to create the synergy of transportation technologies for local delivery. Delivery rate would be 10 to 15 times lower than what home delivery services offer
	SICK Sensor Intelligence	2020	Efficient solutions for Warehouse and Distribution	Article	Overview of field of computer science that focuses on the reconstruction of complex parts of the human visual system, allowing computers to identify and process objects in images and videos in the same way as humans do. Computer vision can identify, track, measure, detect and classify objects. This automation makes it possible to increase performance and production rates, make production more reliable, improve product quality, ensure their traceability, and guarantee safety

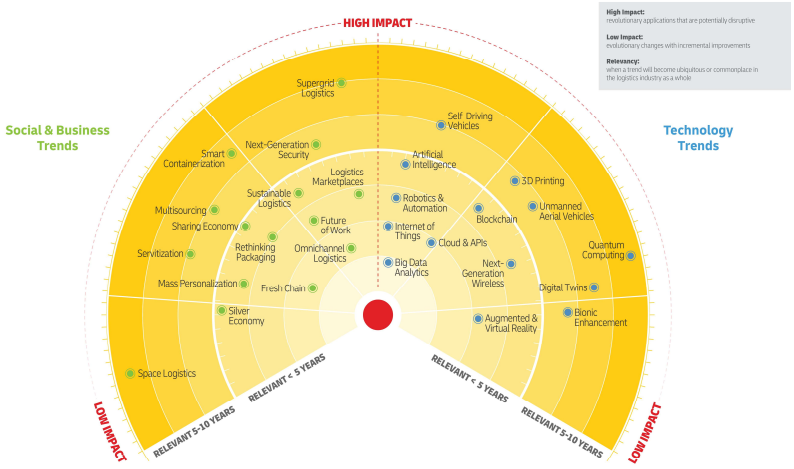
					This technology can deploy in warehouse operation and in last-mile delivery.
	Fujitsu	2017	The World's First Level 3 Autonomous Driving Car Appears at Last: What are the Hot-test AI/IoT Technologies for Automobiles?	Journal	AI will make it possible to meet the challenge of complexity (exploitation of large volumes of data) by providing more reliable indicators to optimize capacities and requests. The level of driving automation is upgrade to appropriate to the circumstances
	Jasper Pickering	2017	This Amazon-style warehouse robot can climb massive shelving units to stack 400 parcels an hour	Blog post	The shelf-climbing robot called Skypods running at Amazon can climb shelf to collect orders. Skypods come and go autonomously to look for products on racks up to ten meters high. Thanks to them, Amazon can store five times more on shelves and the gain in productivity over production time is multiplied by 4. It can process 400 parcels per hour and can carry upto 30kg at a time with speed of 16km/h. It will reduce sorting time.
	JLL	2019	How can parcel lockers improve last-mile delivery?	Article	Providing understand of smart parcel lockers and impact of it to last-mile delivery. The smart locker lowers delivery costs, eliminates the management of unnecessary packages and takes the frustration out of package recipients when late delivery
	La Poste	2019	DPD France launches a parcel delivery line using drones in Isère	Article	La Poste announces the establishment of the first regular commercial line for parcel deliveries by drone. The drone does not emit CO2, it protected natural environment. For the delivery person, in addition to saving time, it is a reduction in road risk on roads. This is a new way of responding to the problem of the last mile, in particular to access areas that are difficult to access
	McKinsey&Company	2017	Automation, robotics, and	Article	To meet huge parcels volume and high demands for fast and free delivery, automating the delivery process is the

	Siemens Logistics	2015	Siemens: 50 years mail sorting automation for Deutsche Post	Press	OCR system can reduce the load of time, effort and money. Unusually shaped letters cause great problems for sorting technology. And as the volume of traditional mail is expected to decline and the share of direct mail such as small parcels is forecast to increase, the proportion of items that are harder to sort will also increase.
	Tim Eick	2019	The learning warehouse – the next quantum leap thanks to artificial intelligence.	Article	Robots may perform tasks that are risky, tedious or repetitive, allowing people to focus on things that required creative thing and less manual. It make operation in warehouse more easier. Artificial intelligence makes the warehouse of the future more dynamic, more agile, and more responsive. It is like a breakthrough and a leap forward for process optimization based on development of intelligent machine systems.
	United States Postal Service	2018	Autonomous Mobile Robots and the Postal Service	Report	Technology helps reduce operating costs and achieve good productivity in a warehouse while ensuring optimal planning of transport and handling operations. Consequently, the risk of injury is limited, the manual transfer of products is eliminated and the punctuality of deliveries and the preservation of the environment of the development areas are guaranteed.
	Universal Postal Union	2019	The digital economy and digital postal activities – a global panorama	White paper	This report presented the global and regional trends of digital postal service. The transformation of digital economy impacts the postal networks. The AI technology use in postal automation, potential application of IoT
	Vipul Chawla, Dong Sam Ha	2007	An Overview of Passive RFID	Article	RFID improved the postal logistics processes, advanced shipping notices, enhanced tracing and tracking mails and parcels with greater convenience and accuracy. Thanks to these advantages, the RFID can speed up mails and parcels sorting but the price is really expensive than barcodes.

	WIK Consult	2013	Review of Postal Operator Efficiency	Report	Understand the background of operators, the increase of mails and parcel volume and overview of mails and parcels operation. Then analyze the AI technology can be applied in sorting centers or delivery process to improve profit and enhance quality of services.
Advantages and disadvantages	Boston Consulting Group	2015	How Robots Will Redefine Competitiveness	Article	This article analyze that the cost of an industrial robot will, on average, drop by 22% by 2025 compare to 2005. At the same time, their efficiency will increase by 5% per year. And if human employment may be threatened, the competitiveness of companies will gain: robotization will drop the average cost of global labor
	Capgemini	2019	The last-mile delivery challenge	Report	Autonomous delivery robot will automate the last mile delivery and delivery of packages from the couriers to the customers. According to the new demand of consumers who want quality of service, flexibility in delivery schedules at the lowest prices, last-mile delivery creates a very competitive market, becoming a priority than ever before of all parties of the logistics and trade sector
	Georgios Petropoulos	2018	Work in the Digital Age	Book	Ai can help people get rid of a tedious task but this also threaten employee jobs. This problem affects one of the most fundamental pillars of current society: employment and the market work
	IBA Global Employment Institute	2017	Artificial Intelligence and Robotics and Their Impact on the Workplace	White paper	This provided the overview of AI on the labor market. It bring the point of view of risks and opportunity of AI for future of the workplace. It also mentioned to advanced training issues and the cost of investment AI.
	McKinsey&Company	2016	Parcel delivery: The future of last mile	Article	The world is ready for autonomous vehicles will deliver 80% of packages. customers can rely on the AI technology in last-mile to facilitate their work and keep track of goods throughout their journey to ensure optimum availability and timely delivery. Indeed, it can help improve the
					visibility and maximize the efficiency of the supply chain, from the warehouse to the final destination
	Pre Scouters	2019	How will AI impact the transportation industry?	Blog post	This post presented the impact of AI in transportation in benefits and drawbacks. Labor costs in this industry will continued to drop with the use of AI. The issue of long hours of driving and stopping for a break will no longer be an issue with fully automated fleets. Beyond simple labor costs, safety and traffic accidents will be greatly affected by AI.
	PwC	2017	Sizing the prize	Article	Global GDP could grow 14% by 2030 thanks to AI. The productivity gains generated by artificial intelligence technologies should represent half of the expected economic benefits. All industries and businesses will be impacted by AI in one or another way, the postal industry is no exception. But financial is one of the issues of SMEs when adoption AI.
	PwC	2018	AI will create as many jobs as it displaces by boosting economic growth	Press	Like every industrial revolution, the advent of artificial intelligence will eventually be accompanied by the appearance of new professions. In other areas, more new jobs created by AI, to optimize the balance. As stated in PwC's prediction, jobs in many sectors are replaced by AI, while new jobs will appear.
	PwC	2018	Workforce of the future	Press	Automation will force 3-30% of workers worldwide to change jobs or need to upgrade their skills by 2030. low educated males could face a highest risk of almost 60% by the 2037s, while low educated females can face 30% risk of automation. Medium educated males and high educated males face a roughly equivalent risk 30%-35%, while medium educated females and high educated females only face a lowest risk with 10%. The effect of AI on men is greater than that of women in the long run.
	Roland Berger	2017	Future of Work	Article	Handling costs today would be reduced by 20 to 40%, according to the research firm Roland Berger. Hence similar

					controversy also erupted in the postal industry over whether robots are the enemy of humans? On the one hand, those who claim that robotics creates new professions, on the other, the most pessimistic, convinced that robots will replace humans.
	Vitaly Kuprenko	2019	How AI Changes the Logistic Industry	Blog post	Implemented AI in distribution centers can enhance the quality of logistics process and has the ability to dramatically increase human capabilities. The potential of AI was decreasing delivery times: customer satisfaction, reduction in stocks. Reducing in logistics costs: increased productivity, optimization of logistics tools, improved responsiveness, improved surface area. It also improving of product monitoring: traceability, locating, control flow and minimizing work accidents, improving work environment
	World Economic Forum	2016	The Future of Job: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution	White paper	It is impossible to say precisely what types of professions will be created with the rise of AI. However, one thing is certain: there will be a lot of novelty and new career opportunities. Based on a study conducted by World Economic Forum, 85% of the professions of 2030 do not exist today.
	WIK Consult	2016	Technology and change in postal services – impact on consumers.	Report	This report analyze of demand for postal and parcel services and using AI technology in sorting and delivery susch as automated vehicles, drones or robotics. It also examine the impact of AI in postal companies and on customers

Appendix 2: Logistics trend radar (DHL)



Appendix 2. Development of digital postal services in Europe and CIS (UPU)

In the table below, “O” indicates an e-service are being provided by designated operators (DOs), while “D” shows an e-service that is not currently offered but is being developed by DOs.

		Europe and CIS																
		Albania	Azerbaijan	Belarus	Bosnia & Herzegovia	Bulgaria	Czech Republic	Hungary	Kazakhstan	Kyrgyz Republic	Republic of Macedonia	Republic of Moldova	Romania	Russian Federation	Slovakia	The Republic of Tajikistan	Turkey	Ukraine
E-post and e-government	Postal electronic mailbox			O	D			D	O									
	Online direct mail			O	O			O	O					D				
	Postal registered electronic mail			D			O	D	O					O			O	
	E-cards			O	D		O	O	O				O					
	Online burofax			O														
	E-Invoicing			O				O	O					O			D	
	Hybrid mail			O	O	O	O	O	O		O			O	O		O	
	Reverse Hybrid mail							O	D						O			
	Online facilitation of hybrid mail				O			O	O					O				
	Electronic postal certification mark						O	D										
	Digital signature		O				O	O						O				
	Digital identity services						O	D	O									
	Credentialing services								O									
	Digital archive						O		O						O			
	E health services													O				
	E-administration								O					O	O			
E-commerce	Online philatelic and postal products shop			O	D		O	O	O		D			O	O			O
	Online postal shopping portal (shopping mall)			O	D		O		O					O	O		D	
	Online customs declaration			O				D	O					O	O			O
	Integration of postal webservices with e-merchants' sites		O		D		O	O	O					D	O		D	O
	Performance reports and analytics				D			O						O	O			
	Virtual international address service								O									
	Calculation of estimated total landed costs			O				O	O			O		O	O			O
	Online management: documents/ merchandise delivery			O				O	O						D		O	
Digital financial and payment services	Online account management								O						O			
	Electronic remittances	O	O	O	D	O			O	O		O		O				O
	Payment solutions			O					O					D	O			
	Online bill payment			O	D				O					O	O	O		
	Escrow services for e-commerce								O									
Support Services	Public Internet access point in post offices		D	O			D	O	O			O			O	O		
	Online information on services and tariffs	O	O	O	O	O	O	O	O	O	O	O	O	O	O			O
	Online lookup (postcodes, addresses, post offices)	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		O
	Online contact and customer service	O		O	O	O	O	O	O		O	O	O	O	O	O		O
	Track and trace	O	O	O	O	O	O	O	O	O	O	O	O	O	O			O
	Electronic notification	O	O	O	D	O	O	O	O			O		O	O		O	O
	Online change of address			O		D	O	O	O						D			
	Holding of mail delivery online	O					D	O							D			
	Online address cleansing services							O							D			
	Electronic postal invoicing			O				O							O			
	Digital postage			O														
	Digital customized postage	O													O			
	Pick up service				O		O	O	O						O			O

Appendix 3. AI application in the warehouse (DHL)

Appendix 4: Delivery Robots (UPS)

Company, Product	Type of Operation	Speed	Weight	Carrying Capacity	Battery Life, Recharge Time	Appearance
Effidence, PostBOT	Follows a person	3.7 mph	400 lbs	330 lbs	8 hours, 4 hours	
Savioke, Relay	Autonomous	1.6 mph	90 lbs	10 lbs	5 hours, 4 hours	
Starship Technologies	Autonomous	4 mph	50-60 lbs	20 lbs	2 hours, 45 min	
TeleRetail, One	Autonomous	5 mph on sidewalks, 20 mph on roads	40-60 lbs	100 lbs	50 miles, 5 hours	
Unsupervised.AI, Aida	Autonomous	Walks 3 mph, rolls at 15-20 mph	60 lbs	20-30 lbs	9 hours rolling or 3 hours walking, 1 hour	

Appendix 5: Warehouse Robots (UPS)

Company, Product	Function	Speed	Weight	Carrying Capacity	Battery Life, Recharge Time	Appearance
Effidence, EffiBOT	Follows a picker autonomously around a warehouse	4.3 mph	285 lbs	660 lbs	8 hours, 4 hours (swappable battery)	
Knapp, Open Shuttle	Transports one or two totes	4.3 mph	260 lbs	230 lbs	4 hours, 1 hour	
Seegrid, GT10 Tow Tugger	Transports carts around a facility	2.6 mph	1,860 lbs	10,000 lbs	8 hours, 8 hours	
GreyOrange, Butler XL	Lifts racks and carries them to pickers	5.6 mph	<440 lbs	3,528 lbs	8 hours, 1 hour	
IAM Robotics, Swift	Robot arm picks items while moving around on a mobile base	6.7 mph	650 lbs	50 lbs	12 hours, 7 hours (swappable battery)