The Impact of Artificial Intelligence technologies on the Employment in Transportation & Logistics Industry in Poland and Ireland.

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MSc in Management of Information Systems

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics.

Signed: ________________________________

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11th June 2018

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11th June 2018

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Abstract

Artificial Intelligence and intelligent, automated systems have been present in many areas of human lives since mid twentieth century. They influence the society and also have a great impact on the job market and the demand and supply of the labour workforce. Transportation and Logistics are the industries that have been heavily impacted by the implementation of new technologies, mostly self driving vehicles, but also Internet of Things, bionic enhancement, usage of big data, machine learning and augmented reality.

In this dissertation the author answers the question of the impact of Artificial Intelligence technologies on the employment in Transportation and Logistics industry in Ireland and Poland. In the first part of the dissertation the author analyses the intelligent technologies and their use cases in Transportation and Logistics. The second part focuses on the research and answers the question of the changes in the labour market in Transportation and Logistics based on the implementation of the Artificial Intelligence.

The quantitative analysis of the secondary data was chosen as the strategy for answering the main research questions and as well as find information on other topics that supporter the proving of the main hypothesis. The author managed to answer the research question with the secondary data research however this method also proved some limitations and it is recommended to conduct further research that would focus on the smaller but more precise sample of data.

The author proves that the implementation of Artificial Intelligence increases the dynamics of the labour market in Transportation and Logistics, however the number of jobs does not decrease. The sector is heavily dependent on the demographic changes in the population as well as the macro-economic factors like GDP.

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1. Introduction

1.1 Context and Background

The speed of the development of new technologies increased in the recent decades. Automatization, increased usage of machines and robots as well as different computing methods have been changing our society constantly for centuries. The society always adapts and changes their lifestyle to reflect the industrial, cultural as well as technological development. The meaning of modern technologies grows steadily. The ones based on binary logic have been taken for granted now and the intelligent ones develop quickly and take over the focus of researchers in different fields of science. The ultimate goal presented by most of the technological companies and research institutes is to make human life safe and comfortable, as well as save our natural environment.

The vision presented in science fiction movies or novels presents robots taking over the world, threatening to destroy the mankind. Different groups of researchers treat this vision as reasonable and probable and analyze the moral, legal and psychological impact of the intelligent technologies on the humanity. Jerry Kaplan in his article “Artificial Intelligence: Think Again” believes in a potential truth of these visions, but he focuses in the society transformation in the first place. Kaplan claims that automation makes the job market highly prone to changes. Robots and intelligent machines can easily perform actions that had to be completed by human employees before (Kaplan, 2017).

Olivia Solon in “The Guardian” analyzes the report published by market research company Forrester, which states that by 2021 6% of the jobs in United States will have been taken over by robots, mostly in logistics and transportation as well as customer service (Solon, 2016). On the other hand Kaplan evokes historical events. In the nineteenth century more than ninety percent of Americans worked on farms on food production. Nowadays the same work has been done by no more than two percent of American labour market and the average cost of it is lower than two hundred years ago. Yet it is not that the outstanding 88% of American citizens are unemployed. Thanks to the automation big part of the work can be done by robots, but it also creates other professions. The standard of life rises, the society grows wealthier, which accelerates consumption and creates demand for new jobs, services and products. Jerry Kaplan says: “our technology continually obsoletes professions but our economy eventually replaces them with new and different ones, there is no reason to believe the historical pattern of job creation will cease" (Kaplan 36-38).

Mariya Yao in her article "AI is turning supply chain logistics into automated trading" defines logistics as a set of action that handles the movement of goods between manufacturers, wholesalers and end consumers. It is a fact that all the largest logistics companies like DHL or Amazon are investing a lot of resources into automation and usage of the intelligent technologies to implement efficiency gains and minimise different types of risk (Yao, 2018).

According to the DHL Trend Research the most influential intelligent technologies are self-driving vehicles, unmanned aerial vehicles, Internet of Things, augmented reality as well as robotics and automation. Uber, Google, Tesla are the biggest companies working on self-driving vehicles, which are supposed to replace human drivers. The commercial use of UAVs will be to deliver goods and products, especially to remote, rural areas. d its potential to connect virtually anything to the Internet and accelerate data-driven logistics. Internet of Things allows that every single object can be connected to the Internet and accelerates the data transport in logistics. DHL researchers estimate more than 50 billion items will be connected to the Internet within the next two years, which will present "an immense $1.9 trillion opportunity in logistics" (Deutsche Post DHL Group, 2016). Augmented reality is an example of technology that increases and helps with the machine-human interaction and collaboration in logistics. DHL and Ricoh have positively tested smart glasses with augmented reality that have been used for order picking. They enable very quick and intelligent solutions in a warehouse. DHL has also tested new generation of robots working side-by-side with people and supporting their repetitive and physically demanding tasks (DHL Global, 2018).

1.2 Research Question

The main research question posted by this dissertation is:

- What is the impact of Artificial Intelligence technologies on the employment in Transportation and Logistics industry in Ireland and Poland?

To answer this question, the dissertation discusses other topics:

- What are the AI technologies implemented in the Transportation and Logistics vertical with the largest impact on the employment structure?

- What processes have been automated, optimized, removed, which resulted in ramp down or ramp up of certain jobs in the Transportation and Logistics?
- What demographic changes do we observe currently in Poland and Ireland?
- What is the change in the employment structure in general?
- What is the change in the employment structure in Transportation and Logistics?
- How did the salaries change in the recent years in Poland and Ireland?
- Did the change in salaries impact Transportation and Logistics?

1.3 Research Interest and Beneficiaries

This dissertation presents a discussion with significant theoretical and practical implications. The study analyzes the impact of new, intelligent technology on the job market and discusses the shift in the skillset of the future employees in Transportation and Logistics vertical. The findings presented in the dissertation can be used by education departments as well as by government officials working on the demographic structure of the society. Education departments can find insights on the transformation of the job market and the skills that may be required by employers in the future. Sociologists and governments will understand better the sociological structure of the population of employees in the sector of Transportation and Logistics. This study will also benefit other researchers who aim to study the impact of Artificial Intelligence on the job market.

1.4 The Scope of the Study

This study analyses Irish and Polish Transportation and Logistics vertical. It examines the changes in the employment market caused by the implementation of intelligent technologies. It investigates jobs that disappeared or have been replaced by machines as well as new professions that developed together with the expansion of Artificial Intelligence in Transportation and Logistics. It also analyses the changes in the skill set as well as education of employees in the past decades in Ireland vs. Poland.

1.5 Chapter Roadmap

Chapter 1: Introduction

This chapter presents the context and rationale for the study. It introduces the relevant background information on the intelligent technologies used in Transportation and Logistics and on the impact of Artificial Intelligence on the job market.

Chapter 2: Literature Review

This chapter puts forward the theory of Artificial Intelligence. It gives historical background, definition on the term and discusses different methods used by AI technologies. Further it presents the usage of AI in Transportation and Logistics.

Chapter 3: Methodology
In this chapter the author gives an overview of the research method. The methodology of data collection and analysis is presented.

Chapter 4: Analysis and Findings
Chapter four evaluates and interprets the collected data and presents the results of the analysis.

Chapter 5: Conclusions
In this chapter the author presents conclusions from the analysis of data and discusses whether the research findings have answered the research question.

2. Literature Review

2.1 What is Artificial Intelligence

2.1.1 History

Computer science and technology has been dominated by Artificial Intelligence (AI) in the recent decades, but it does not mean that this is a new topic. Some of authors even claim, that we can look for the initial source of AI in ancient Greek culture, where it was represented as the Antikythera mechanism. Others would assign AI to Leonardo da Vinci's inventions. People kept trying to define human thinking processes and to build machines that deliver intelligent solutions. Decision making process, understanding trends and developing patterns of human logic has been bothering scientists since ancient times (Miladinović, 2018).

The work of Alan Turing has been defined as the most influential for the early Artificial Intelligence studies. Turing gave lectures on AI at the London Mathematical Society in 1947 and presented his well structured vision on machine learning, genetic algorithms and reinforcement learning in this paper "Computing Machinery and Intelligence", that was published 1950. John McCarthy though was the first scientist that used the term "Artificial

Intelligence” in 1956. He also established the the Stanford AI Laboratory and was awarded with the Turing Award (Miladinović, 2018).

Early usage of Artificial Intelligence focused on games. One of the most popular examples is the computer Deep Blue, which was developed by IBM and programmed to play chess. Deep Blue was a great success and it even won a chess game against Garry Kasparov - the world champion and unquestionably the best chess player in the human history (Bundy 2017). Machine won against the human mind.

As the technology evolves, the term AI encompasses more and more areas. Activities that would be classified as AI decades ago became broadly used, day-to-day technology. For example computers able to recognize optical characters used to be classifies as AI, but became standard technology today. Currently scientist list the following activities as Artificial Intelligence: speech recognition and understanding, self-driving cars, intelligent navigation and traffic control, intelligent routing in content delivery networks, warehouse and logistics management, interpretation of complex data, ability to compete in complex strategic games as military simulations and many more.

2.1.2 Definition of Artificial Intelligence

Artificial Intelligence is a science that includes fuzzy logic, evolutionary algorithms, neural networks, artificial life and robotics. It focuses on concepts like voice recognition, image identification, natural language processing, expert systems, neural networks, planning, robotics, and intelligent agents. AI is an universal research field. It involves machine learning and perception and goes into very specific actions like playing strategic games, creating poems, proving hypothesis in mathematics, diagnosing health issues, preventing and healing diseases, managing a warehouse, driving a truck etc. Every task that requires human intellect, is interesting to AI researchers (Norvig & Russell, 2010). Some of these conceptions will be described further in this paper. As an IT department AI focuses on building models of intelligent behavior as well as computer software and machines that simulates this behavioral patterns. It solves problems that can not be effectively presented as algorithms. Intelligent computer programs can engage in intelligent planning (for example setting up traffic lights to enable effective traffic management), recognize voice and convert it into a written language, translate natural languages, act like an expert (diagnose a disease based on symptoms) and many more. Artificial Intelligence is a science that gets input from various other knowledge fields and it uses models and methodologies coming from statistics, computational intelligence and traditional symbolic, mathematical optimization, logic, probability methods, economics and more. The most important questions that AI is trying to answer is how to effectively represent knowledge, how to build a reasoning as well as learning.

2.1.2.1 Intelligent Agent

Artificial Intelligence has been discussed by scientists as a research of “intelligent agents”. Intelligent agents are artificial machines with the ability to investigate and understand their environment and act based on this examination to accomplish their goals. Cognitive skills of an intelligent agent and their potential to solve complex problems are similar human abilities.

According to Nikola Kasabov and his article “Introduction: Hybrid intelligent adaptive systems” , intelligent agents have the following abilities:

- Ability to analyze their own reactions, their behavior in certain situations.
- Ability to analyze big sets of data and draw conclusions.
- Ability to evaluate failures and successes.
- Ability to learn new problem solving methods.
- Ability to adapt their behaviour immediately.
- Ability to interact with the environment and learn new skills typical for certain situations.
- Ability to use their memory system to store patterns of behaviours, problem solving methods, skills etc (Kasabov and Kozma, 1998).

2.1.3 Artificial Intelligence Methods

As mentioned previously AI works with fuzzy logic, evolutionary algorithms, neural networks, artificial life and robotics. The science increased the speed of its development in the last decade but its basis and inspiration are theories, research methods and studies that have been existing for centuries: metallurgy or statistical physics (visible in the method of simulated annealing), evolutionary biology (adapted by AI as genetic algorithms), economics (market-based algorithms), entomology (ant colony optimization) and others (Norvig & Russell, 2010).

2.1.3.1 Fuzzy logic

Fuzzy logic is a term that represents a logic with truth values between 0 and 1. Its form is contrasting with the binary logic, where the values can only be a real number 0 or 1. Fuzzy logic can conceptualize the partial truth, where the truth value could be located between completely true and completely false. It is a method for rationalizing with logical expressions describing participation in fuzzy sets. What makes fuzzy sets useful is the possibility to set "hedges" - descriptive modifiers that act as a model of fuzzy values. Thanks to these modifiers fuzzy logic enables operations to be closer to natural language and to develop fuzzy statements through mathematical calculations (Kay, 2018).

2.1.3.2 Evolutionary Algorithm

Evolutionary algorithms (also called genetic algorithms) have their source in genetic biology. Evolutionary algorithms in AI transform the knowledge from the theory of evolution, like natural selection, reproduction, mutation, recombination to the modern IT solutions. It is a form of stochastic beam search, where the successor states are developed through a combination of two parent states. The population is characterized by a fitness function, which decides on the pairing process. The pairs produce offspring that is subject to mutation. In the problem solving process different solutions play the role of individuals in a population. The best solution wins and gets implemented. Repeated action of choosing the best solution brings the evolution of the population. Evolutionary algorithms are based upon an assumption, that the input of a series of small mutations to a computer program can support the program to achieve better performance (Norvig & Russell, 2010).

2.1.3.3 Artificial neural network

Human's mental activity is primarily based on the electrochemical activity in networks of brain cells called neurons. This hypothesis inspired AI scientists, whose aim was to build a computer system that simulates human brain and human thinking process. This initiated the concept of a neural network, which describes a set of units connected together. IT researchers have been exploring neuroscience since 1943 and got especially interested in the abilities of neural networks that are more abstract than just a connection of brain cells. They have been focusing on the "ability to perform distributed computation, to tolerate noisy inputs, and to learn" (Norvig & Russell, 2010).

2.1.3.4 Simulated Annealing

Simulated annealing comes from metallurgy and has been used to temper or harden metal and glass. The substance is heated to a high temperature and then gradually cooled. This procedure allows the substance to reach a low energy crystalline state. If the process of cooling a liquid or a metal happens gradually, the molecules form a relatively uniform structure. If the cooling is rapid, the structure of the molecules will be more chaotic. When the annealing algorithm initiates, its functioning resembles liquid or metal in high temperature. The algorithm can propose many different configurations in a short period of time. The longer the algorithm runs, the more effective are the suggested solutions. At the end of the operation the probability of suggesting an ineffective solution is close to zero.

Russel and Norvig (2010) describe simulated annealing as a method to develop intelligent systems. The authors compare it to a ping-pong game on a bumpy surface. The goal of the game is to place the ball into the deepest hole in the surface. At the beginning of the process, if we shake the surface the ball stabilizes in any hole that is deep enough. The intensity of the shaking decreases gradually as the metal cools off and the ball is more likely to stabilize in the suitable hole. Simulated annealing method focuses on random actions at the beginning of the process. These random actions are accepted whenever they have positive impact. The probability of the solution being changed at the beginning of the process is higher (in the high temperature) and it decreases towards the end of the process (the cool-off phase). The process slows down gradually and the algorithm finds the optimal solution. Simulated annealing was developed in 1980 and since then if has found many applications in large-scale optimization tasks.

2.1.3.5 Ant colony optimization algorithm

Ant colony optimization algorithm comes from generic heuristics. The term was used for the first time by Marco Dorigo in 1991. His first algorithm was meant to find the best path following the behavior of ant colony searching for food. The algorithm has evolved and is currently used to search for solution to wider class of numerical problems (Colorni, Dorigo & Maniezzo, 1991). This algorithm is a probabilistic method to solve computational problems through following the right paths of action with the usage of graphs.

In the natural environment ants choose their travel paths randomly until they find the source of nutrition. When this has happened, ants sign their paths with pheromones, guiding the colony to the food source. These pheromone trails help the whole ants population, because they do not have to start their food search through traveling at random. With the time the pheromone paths evaporate and are less likely to draw attention of the ants. The density of travel on the short trails is higher so the shorter the pheromone path the longer it lasts. The pheromone strength of the long trails is evaporating faster, because it takes longer for each single ant to travel to and from the nutrition source. The evaporation of the pheromone trails has its advantages though. It motivates the colony to search for other nutrition sources through their random travels.

When we translate the phenomenon of ants searching for food and marking their paths with pheromones to technology, the evaporation of the pheromone path brings exploration of new solutions and innovative results. The ant colony optimization algorithm simulates the behavior of the ants. Ants that follow the pheromone trail symbolize the positive feedback and positive solution whereas ants searching randomly for a nutrition source represent the problem to solve (En.wikipedia.org, 2018).

2.1.3.6 Artificial immune systems

Artificial immune systems describe intelligent algorithms mirroring the processes happening in the organism of animals to fight antigens. The biological immune system is able to learn, remember and mutate to improve its abilities to suppress antigens. It is also a great "problem-solver". In Artificial Intelligence the immune system algorithms focus on transpose the structure and functionalities of the biological immune system to computer science to solve mathematical, statistical and other IT problems. Leandro Nunes de Castro and Jonathan Timmis (2002) in the book "Artificial Immune Systems: A New Computational Intelligence Approach" define the artificial immune systems as "adaptive systems inspired by the biological immune system and applied to problem solving".

2.1.4 Knowledge representation, Reasoning, Learning

An important task of AI systems is to build connections between different facts and develop the knowledge in a form that would be understood and acted by by machines. The knowledge is build of facts, that can be either true (1), false (0) or between the complete true and complete false value ($>0 \wedge <1$), as fuzzy logic allows. Organized facts can be defined as information and information that is up for being understood and acted by can be defined as knowledge.

For the AI models to use the knowledge it has to be presented in a specific way. Initially computer software used symbolic representation like semantic nets, which were directed graphs of facts with added semantic content. At a later stage the semantic nets started including more facts and the form of knowledge became defined as frames. Another way to structure knowledge is as logical expressions. This method was initiated by George Boole and his name is now defining the 1-0 logic representation (Boolean system). The next stages of knowledge representation were quantified expressions and later programming logic with the first programming language called Prolog (Whitson, 2016).

The next task of AI systems is to understand the information and document the steps for arriving at a conclusion. Reasoning process explains, how information develops and how the connected facts contribute to forming new information. The reasoning method depends on the form of knowledge representation. For example if the knowledge format is the semantic net, then the reasoning process happens with the decision tree search method. The reasoning process in programming languages happens through an inference engines, for example back-chaining or forward-chaining technique.

To learn is another crucial task of intelligent systems and it aims on expand and / or modify the knowledge of the system. For the semantic net and logic programming mentioned before, learning process happens through adding or changing the nets or rules.

2.1.4.1 Expert Systems

As mentioned before one of the focuses of AI researchers is the practical application of the intelligent systems. One of the areas that has been very successful and has been used in the day-to-day life are the expert systems. Expert systems help to make decisions. The commercial, medical and scientific use of expert systems is broader every year and the common usage allows the systems to learn - gather more facts and turn them into knowledge. Expert systems can be divided into different categories but the best known expert systems are rule-based systems. Rule-based expert systems uses the knowledge based on rules, that consist of if-then statements. There are multiple antecedents (which are statements that can be true or false and depend on information that was the input for the system) and different consequences.

An example of the great impact of expert systems on our daily life is in the medicine. To develop a diagnosis and complete the healing method, doctors have to go through a complex reasoning process. For human brain the process is influenced by many factors and also by the human intuition. In contrary to machines, people are not able to analyze big amount of data and solve multiple problems at once, that is why their decisions are often influenced by assumptions, precedences, cultural regulations, even feelings. In medical analysis, the expert systems are able to analyze countless symptoms, pros and cons of various approaches, look at genotype, historical illnesses in the family etc. The thinking skills of human brain will never reach the same level of this complex analysis and will be more prone to mistakes than the machine equipped in Artificial Intelligence software. Additionally the expert system here is able to learn to distinguish the relevant information from the obsolete. Verifying the correctness and handling wrong or false information is also a big value and minimizes the risk of taking the wrong decision (Hall, 2016).

2.2 Artificial Intelligence in Transportation Systems

Science has been looking for solutions to simplify and optimize transportation and logistic systems for a long time. Apparently already Roman civilization implemented specific rules on their roads to make sure the traffic flows smoothly. The twentieth century introduced various traffic rules and policies (speed limits, bans on overtaking, reversible lanes, roundabouts etc.) as well as traffic lights to regulate the transportation activities on the road. Intelligent systems have been slowly taking over control over traffic and transportation (Bazzan & Klügl, 2014).

Ubiquitous computing, internet of things and other intelligent products are getting more and more popular in transportation and logistics. The term Intelligent Transportation Systems (ITS) involves five different areas:

1. Advanced Transportation and Traffic Management Systems (ATMS)
2. Advanced Traveler Information Systems (ATIS)
3. Advanced Vehicle Control and Safety Systems (AVCSS) or Advanced Driver Assistance Systems (ADAS)
4. Advanced Public Transportation Systems (APTS)
5. Commercial Vehicle Operation Systems (CVO).

Ana L.C. Bazaan and Franziska Klügl (2014) in “Introduction to Intelligent Systems in Traffic and Transportation” focus on the two first (ATMS and ATIS) and present the impact of Artificial Intelligence on the evolution of the road transportation services. ATMS is the system that controls traffic devices (traffic lights). It it also enables the communication between different agents in the system, such as traffic signal controllers, traffic monitoring devices, devices monitoring emissions and helps to manage extreme situations, emergency situations, etc. The aim of ATIS is to provide information to the users of the roads. Usually the information is first gathered and processed by ATMS and then communicated through ATIS with the support of navigation devices and other broadcasting tools.

Information systems experts have been working on making intelligent traffic technologies innovative and user friendly. Some technologies of ITS are based on computational solutions, but rather use the binary logic and do not include the methodologies specific for Artificial Intelligence. The questions that ITS technologies try to answer are about choosing the best route, is it necessary to reroute, how does the traffic density impacts the transportation times, is the fastest route really the best one.

Identifying the best route from point A to point B has not been a big challenge for the modern technology. The task for intelligent solutions though is to deliver real-time output in the event of unusual occurrences and disruptions. Besides answering the standard 1-0 questions regarding route definition AI solutions should dynamically anticipate the driver's behaviour, draw conclusions from the circumstances and give advice. Bazzan and Klügl name many more use cases for intelligent systems to support transportation and traffic: ramp metering, emergency services, crisis management, enforcement of traffic laws, parking management, fleet management (trucks, taxis), communication with drivers, electronic toll collection, road pricing, mass transit smart cards, collecting weather data and its influence on the traffic (Bazzan & Klügl, 2014).

2.2.1 Artificial Intelligence in decision taking process

2.2.1.1 AI in traffic modelling

Artificial Intelligence supports the decision taking process in the traffic modeling and simulation. AI solutions develop models that are more effective and more precise than models created by people. The AI models are comprehensive, they analyze extremely large data sets for all different variables. Bazzan and Klügl (2014) describe the agent based AI models and identify two different layers - tactical, physical layer and strategic, mental layer. The tactical layer is modeled based on the traditional traffic flow simulators and it regulates the behaviour of the road user respecting the unconscious behaviours. This layer connects the road user with their environment - the road, infrastructure, information about other users of the road. The input comes from the local source (user's perception of the road) and the external sources (radio, applications on the mobile phone and other broadcasting tools). The strategic or mental layer impacts the driving itself - the acceptable distance between the vehicles or between a vehicle and obstacles, the acceptable speed of the car etc. The goal of the trip as well as the preferred route belongs to the strategic layer as well. The next paragraphs will show how Artificial Intelligence models influence the layers and how they interact.

2.2.1.2 Individual decision making models

2.2.1.2.1 Anticipation

Anticipation is one of the focus areas for intelligent models for traffic management. The vehicles with intelligent traffic management systems are supposed to define their behaviour on the road in the best way possible. They are supposed to adjust the speed to the road conditions, keep the adequate distance to the vehicle the front, stay in the lane, decide about other maneuvers on the road for example overtaking, changing the lane etc. The vehicle reacts pro-actively to the events on the road. The intelligent agent changes its behaviour real time based on the environment and their intelligent decision taking process creates the traffic flow and the stop-and-go waves (Bazzan & Klügl, 2013).

2.2.1.2.2 Behaviour at crossings

The traditional traffic simulators do central crossing management using a controller that opens and closes certain routes. The drivers adjusting their behaviour on the road and speed to the visual signs on this particular crossing. To manage the crossroads in this way is not a challenge for intelligent systems. What is challenging though, are the crossroads without central traffic lights regulation or any other controller. Artificial Intelligence comes into play when we search for intelligent solutions for events in which the drivers behaviour is based on the drivers observation, knowledge and decision. Also the existence of road regulations and driving laws does not mean that they are obeyed by each single driver and user of the road. Arnaud Doniec (2008) in his paper "A behavioral multi-agent model for road traffic simulation. Engineering Applications of Artificial Intelligence" presents the intelligent driver-agent coordination model. An agent approaching an intersection obeys the priority law (for example right before left) and projects this regulations on the traffic situation. The same agent also anticipates the reaction of other agents, that are present at this time on this particular intersection. The agent gives the way to the agent who has the priority based on the traffic rules, but it also constantly observes the environment and decides if other laws should be applied. For example if the waiting time on the crossroad is longer than expected, a human driver would become impatient and go first disregarding the traffic rules. According to Doniec an intelligent agent is able to take decisions ignoring the law, just as a human driver would probably do, but only after comprehensive and detailed analysis of the conditions (Doniec, 2008). This is supposed to be the advantage of the self-driving cars. An autonomous agent observes and analyses the intersection. If other vehicles in the do not follow the road rules and do not respect their priority, it moves slightly forward to inform the other drivers about its intention and cross the intersection safely. According to Google engineer Chris Urmson programing this kind of behaviours to an autonomous agent is absolutely crucial, otherwise they would never be able to join the real world. (Guizzo, 2017).

2.2.1.3 Artificial Intelligence in routing planning

As mentioned before Artificial Intelligence models in the traffic situation work with the two-layered architecture - the tactical, physical layer and the strategic, mental layer. The intelligent agent not only decides about the best route to get to his target location but it also settles on the plan regarding the time to leave, vehicle to take etc. Route planning and re-routing is a task simple enough for the traditional, automated systems. However, the intelligent models involve immediate re-routing based on the anticipated conclusion, which is defined with the term en-route planning. The advantage of AI in traffic simulation over the automated models is the ability to combine different reasoning components and develop a complex agent architecture. The intelligent models are also able to adapt real-time to the external conditions. For example if route would include multiple destinations and the vehicle is stuck in traffic, the system would cancel one destination in between based on the priority of the destinations and the general effectiveness of the route. The models would prioritize and deprioritize certain actions to make sure the final goal is achieved. As Bazzan and Klügl (2013) state, “by the inclusion of all choices in an integrated way, behavioral consistency can be guaranteed”.

2.2.1.4 Traffic congestion identification

Every single user of the road can now use the intelligent technologies provided by their mobile phones - it does not require any investments in additional machines like sensors or cameras to use AI on a daily basis. Smartphones have the ability to get real-time data about the traffic and are equipped with intelligent systems that supports the users with decision making processes. The main advantage of mobile devices is the possibility to describe its exact position. According to Ana L.C. Bazzan and Franziska Klügl (2013) “there are two ways of location positioning: (i) handover from one cell to another (in which accuracy depends on the density of antennae); and (ii) triangulation based on the signal strength from different antennae. Identifying the location of the smartphone also allows to identify the speed of the vehicle and the direction to forecast the time of the travel. The density of mobile phones in one area supports monitoring of the traffic congestion. Based on these signals traffic control systems are able to schedule the movement on the roads. First experiments with the traffic control using mobile devices were conducted in the year 2000 and this technology is currently broadly accessible and used both commercially and privately around the world. Google Maps is a great example here, but there are also other companies that provide similar services - Estimotion (individual services), Mediamobile (traffic and weather services).

2.2.2 Usage of Artificial Intelligence to schedule track deliveries

Artificial Intelligence has played an important role in the route planning for the truck drivers. Evolutionary algorithms, simulated annealing, artificial immune systems and ant colony optimization mentioned earlier in this thesis are methods used widely for the logistics and truck delivery automation. Bogna Mrówczyńska (2015) in her paper “Multicriteria vehicle routing problem solved by artificial immune system” presents the intelligent solution used to automate truck delivery. The foreign bodies attacking the system are pictured by the author as a graph representing the road connections and delivery points.

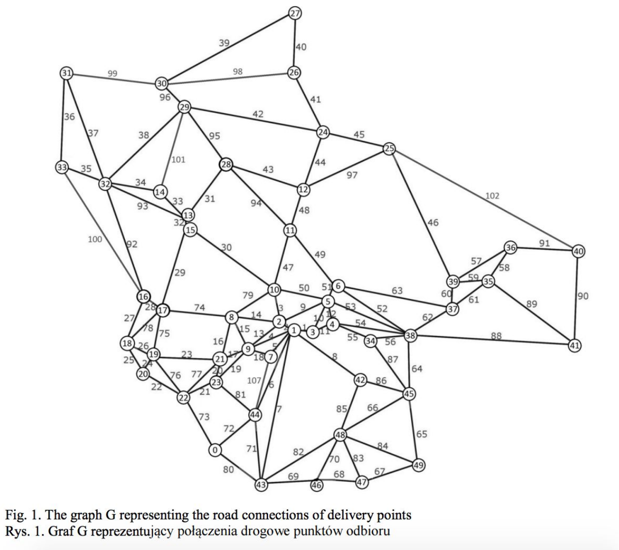

Figure 2.1 Representation of road connections of delivery points (Mrowczynska, 2015)

The below function presents the way how the antibodies get created, with the rule the higher the value, the better the antibody and the more it should be cloned.

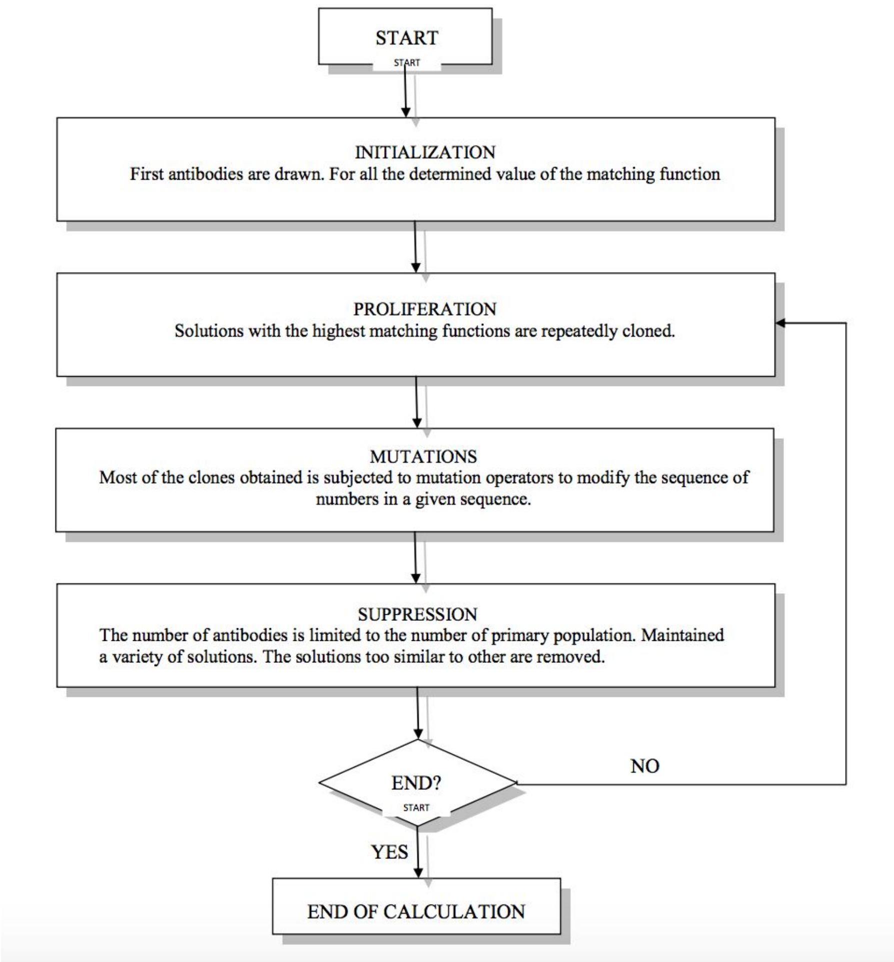

Figure 2.2 The immune system method (Mrowczynska, 2015)

Artificial Intelligence expedites and increases the efficiency and reliability of the planning of truck delivery. Artificial immune system respects all the all the necessary variables to create the schedule: the route, travel time, the limits on the capacity, time windows of supplies and the working hours of the drivers etc. The result of the calculation presented in the above figure is the most optimal solution for the given environment (Mrówczyńska, 2015).

2.3 Artificial Intelligence usage in Supply Chain Management

Supply chain management is an oversight of the process of operational series that link manufacturers to suppliers, manufacturers to wholesalers, wholesalers to retailers and retailers to the end user. Logistics is the part of operations that focuses on the movement of goods. The investment in Artificial Intelligence solutions into logistics and supply chain management has been enormous recently, as it may offer a significant increase in efficiency and decrease of cost with a reasonable cost of investment. Intelligent solutions are also an answer to the most pressing pain points of the supply chain management business - they offer solutions that do not fail and can be used on a large scale (Yao, 2017).

In the article “A.I is turning supply chain logistics into automated trading” the author Mariya Yao interviews Chad Lindbloom, the CIO of C.H. Robinson, an american Fortune 500 transportation company. According to Lindbloom, the level technological development is the differentiating factor in his industry, as the whole logistics industry aims on increased efficiency and reduced cost. Companies like DHL, Active Ants, Locus Robotics, Honda leverage intelligent technologies like autonomous cars, wearable technologies, robots, smartphones applications and more (Yao, 2017). DHL’s 2016 Logistics Trend Radar anticipates that artificial intelligence investments will continue to grow as the number of companies that invest in research and development of AI solutions in-house raises continuously (DHL Trend Research, 2016).

The Logistics Trend Radar mentions 12 main technology trends that keep changing the supply chain management systems:

- 3D printing
- Augmented Reality
- Big Data
- Bionic Enhancement

- Cloud Logistics
- Digital Identifiers
- Internet of Things
- Low-cost Sensor Technology
- Robotics & Automation
- Self-driving Vehicles
- Self-learning Systems
- Unmanned Aerial Vehicles.

2.3.1 Augmented Reality

The growing consumption of goods increases the need to manufacture and distribute products around the world. This increases the meaning of efficient logistics chains. Effective management of warehouse operations plays an important role in the supply chain it belongs to and Augmented reality is one of the intelligent technologies that support lean improvements in SCM. Augmented reality technology connects the physical and the digital world in real time using some wearable device - for example smart glasses.

As stated before augmented reality is a technology that allows to combine virtual elements to real, physical world in real time and integrates them in a 3D environment and helps the user to understand their surroundings. The task where this technology has been most significant is the order picking in a warehouse. Order picking accounts to more than half of all warehousing costs and this can be influenced by the efficiencies created by the augmented reality, which is supposed to route the human operator through the warehouse and result in increased process efficiency, higher quality, lower risk and less stress of manual handling (Augmented Reality in Warehouse Operations: Opportunities and Barriers). Thanks to augmented the employee would get the task list communicated to them in real time (via headphones, some mounted display, smart glasses) and they would be able to find the most effective way to find a storage location of a product. The technology simplifies product picking, packing, sorting and more - the smart devices already have the functionality to display information about the next action, scan barcodes, navigate in a warehouse. Augmented reality can also help with last-mile operations - it removes the complexity from completeness checks of shipments, creating and executing loading sequence of a shipment, navigate to the correct entrance etc. DHL reports that the first deployment of augmented reality for product picking in the warehouse of Ricoh proved 25% efficiency increase (DHL Trend Research, 2016).

2.3.2 Machine learning

Traditional data analysis methods use static historical data, which creates the challenge or quickly outdated results in the fast-changing environment. It needs a model developed on the historical inputs and a human expert to define the relationship between different variables. The developing, intelligent technologies create the need to analyze and understand correlations between millions of inputs from different data sources and machine learning technology delivers this solution. According to Calum McClelland, author of www.iotforall.com the machine learning algorithms begin with result variables and then automatically look for predictor variables and their interactions (McClelland, 2017). As McClelland explains machine learning solves the problem of missing input variables to answer the key question and make final decision. When the algorithm “knows” the final goal, it “learns” from the input data points, sorts out the factors that are meaningful and crates a solution to achieve the final result. The author gives an example of the application of machine learning in Google’s data centers in 2017. Data centers need to maintain low temperature so they need powerful cooling system that use a lot of energy and provide extremely low risk of failure. The cost of proper cooling systems is high, so Google aimed on increasing the efficiency of it using machine learning. The algorithm had the goal of increasing the efficiency and 120 variables (fans, pumps speeds, windows etc.) and managed to build a model that allowed to cut the overall energy consumption by 15%. In the following years this achievement means millions of dollars in savings for a company as big as Google (McClelland, 2017). Another great usage of machine learning is the possibility to predict future events, because the machine learning algorithms “learn” constantly based on the data input that is delivered real-time. They can develop predictions, analyze them against the real events and adjust the algorithm for next predictions to be more accurate.

In the supply chain management the analysis and correction of the logistics data will take a big advantage of the self learning algorithms in the future. For example the shipping systems can be trained to decode the address information on the parcel and make sure to place it in the right place in the delivery chain. The algorithms are also able to understand the root cause and correct the defects which would result in time saving on quality checks and manual work. The self-learning algorithms are also an advantage in other operational aspects, for example the systems using machine learning “learn” to identify frequently appearing events and connect them to specific clients, orders and other variables in the operations. Also the systems could predict the content of an order and “pre-pick-and-pack” in the idle time without waiting for the order to be placed, which increases the utilization and efficiency of the systems and decreases the cost (DHL Trend Research, 2016).

2.3.3 Big Data

As described before, machine learning algorithms are an application of Artificial Intelligence that access databases and “learn new things” in a programmatic way. All AI algorithms require access to large amounts of data - the more data the more accurate the algorithm. The size of data basis is constantly growing and accessing the targeted information has become a challenge (Hansen, 2018).

According to the technology research company Gartner there are around 4.9 billion connected devices around the world like cars, home assistants, appliances, industrial equipment etc. and all of them are continuously generating data. By 2020 Gartner estimates this number to grow to 25 billion. Not only the amount of data is a challenge for data analysis systems but also the quality of it as the datasets collected from the connected devices and sensors differs from the traditional datasets. In the raw state the data is fragmented, disparate in space and time and heterogeneous.

The authors of the article “Big Data” in the leading online publication for the computing and information technology “Communications of the ACM” the big data technology has seen the biggest successes thanks to the availability of large datasets that supported the training of machine learning algorithms. The successful use is seen in applications such as Internet search, e-commerce, placement of online ads, language translation, image processing, autonomous driving (Stonebraker et al., 2018).

Big data has already started to achieve successes in the logistics industry as well. It turns the large sets of data into information that supports efficiency gains in topics like capacity planning, resource optimization or vehicle route optimization as well as increases the speed of decision making process, makes it unified and transparent and decreases the risk of human error. The use case in logistics is that thanks to the intelligent systems based on the correlation of large data streams (for example shipment information, weather, traffic and other conditions) can help with real-time scheduling and assignment of tasks, optimization of load sequences, and precise definition of the estimated time of arrival (ETA). Big data also supports improvements in the customer experience field. It allows to build a complex overview of all interactions with customers, operational performance and challenges.

Through precise customer segmentation and prediction of behaviours the systems can target and tailor the service levels. Another successful feature can be the sentiment analysis that would help deliver high levels of customer satisfaction (DHL Trend Research, 2016).

2.3.4 Robotics and Automation

Artificial Intelligence and other technologies that fall under its umbrella supported the development of robotics and automation technologies. Thanks to the development of machine learning and the sensor technologies in the recent years the robots became more flexible, easier to navigate and more affordable. Robots can significantly improve the efficiency of the warehouse operations with its order picking and order movements abilities. They can intelligently adapt to the surroundings and the navigation technologies help them find the right route from A to B. The warehousing robots are armed with high-resolution cameras and different types of sensors and can be programmed easily. They can also support scaling operations because they can be moved between different warehouses to mitigate the risks of high and low activity seasons. Another use case for robots in the warehouse are the container unloading robots, that take away the physically difficult work from human employees. These robots are equipped in image recognition technology which helps them locate parcels, analyze size and shape, build the most efficient unloading sequence and execute it with its robotic arms armed with sensors and grippers. With the growing e-commerce market and high demand for delivery of small parcels to private clients the use of robots is also in demand. They can help human employees with heavy deliveries, sort parels in the delivery vehicles or even deliver independently to collection points (DHL Trend Research, 2016).

2.3.5 Bionic enhancement

Bionic enhancement technology researches wearables and exoskeletons to improve human physical abilities. Sensors and nanotechnologies innovations allow exploring solutions that can be used in a logistics enterprise. Exoskeletons are robotic additions to the worker’s clothing, that increase their strength and endurance. Exoskeletons help to lift heavy objects, make repeatable manual handling easier and less aggravating and increase the speed and safety of the workers in general. Panasonic has been already testing a Power Loader suit, which is a bionic leg that adapt to the body of the wearing person (Panasonic Newsroom Global, 2014). Such bionic limb enhancements are equipped in onboard computers which detect the exterior and navigate the motion of the enhancement. For example when we talk about leg enhancement, they gain an understanding and adapt to the the gait of the wearer to create a natural walking pattern (Cox, 2016). Warehousing sector could use the bionic enhancements to improve the work environment for the human employees, especially their health and safety. The technology would have a significant impact on the reduction of stress as well as physical struggle and work-related injuries.

2.3.6 Internet of Things

Cisco is an enterprise leading in the Internet of Things research and they indicate that by 2020 there will be more than 50 billion objects connected to the internet. This technology has already been used broadly in business operations, but there is still a large opportunity for improvement in the logistics and transportation vertical. According to DataArt the IoT revolution has not started yet and it is going to change our world significantly. Over the next 5 years different companies are going to spend almost $6 trillion on the IoT research and application in the business operations (IoT For All, 2018). Predictive analytics combined with machine learning would build the strength of the IoT technology, for example sensors attached to machines can “learn” the typical activity of the machine and identify abnormalities (McClelland, 2017). A warehouse that uses sensors to tag objects like pallets, machines, goods can have greater transparency of these assets, as these sensors can pass on information about the location of the object, order, content of a package, which makes it possible to automatically manage inventory and have a real-time visibility in the stock and condition of the goods. Another use case of IoT in a warehouse could be to use them for the workforce to optimize things like lightning in a warehouse, heating or cooling and improve the working conditions of the warehouse employees (DHL Trend Research, 2016).

2.4 Self driving vehicles

DHL Trend Radar mentions self driving vehicles as a technology with high impact on logistics in a time frame longer than 5 years, however the impact of Artificial Intelligence technologies on the transportation and logistics can already be observed and they have also started re-shaping the job market. In the report published in December 2016 the White House predicts that more than 3 million truck drivers may lose their jobs due to the growth of self driving vehicles industry, however it does not specify the timeline (Greshgorn, 2016). The bad news for truck drivers as well as delivery drivers and taxi drivers is that they face almost full automation of their work. Artificial Intelligence has already started playing an important role in managing their daily routine on the road and helping them to simplify it and increase efficiency.

2.4.1 Autonomous cars definition

Self-driving cars are vehicles able to gather data from the environment, analyze it, draw conclusions and act upon them as well as “learn” for the future without human input. The vehicles have the ability to navigate on the road in the usual traffic situation and in a closed surroundings like warehouses. Fully automated cars able to drive without human involvement exist already, however they are not allowed to take part in the traffic yet (Wikipedia, 2017).

2.4.2 Autonomous cars benefits

Three companies made significant progress in experimenting with autonomous cars on the roads - Google (with their technology Waymo), Tesla and Uber. They claim that the ultimate goal of introducing and including the technology of self driving vehicles in our day-to-day life is to make the roads safe through reducing the risk of human error, which causes car accidents resulting in death, injuries etc. Another benefit is the optimization of traffic flow, easy access to transportation for people that are not independent drivers, for example individuals with health issues. The technology would optimize the traffic in the cities through enabling usage of parking space and it would support crime reduction, because the car does not have to stop and wait for the driver in the same place. Another benefit would be new business models based on mobility (Wikipedia, 2017). According to the World Human Health Organization more than 1.2 million people die every year in traffic accidents. Sebastian Thrun, Software Engineer in Google explains: “We believe our technology has the potential to cut that number, perhaps by as much as half. We’re also confident that self-driving cars will transform car sharing, significantly reducing car usage, as well as help create the new “highway trains of tomorrow." These highway trains should cut energy consumption while also increasing the number of people that can be transported on our major roads. In terms of time efficiency, the U.S. Department of Transportation estimates that people spend on average 52 minutes each working day commuting. Imagine being able to spend that time more productively” (Thrun, 2010).

2.4.3 Classification of autonomous vehicles

There is a high amount of automated features in the vehicles that support different driving tasks, but do not make the vehicles fully autonomous. For example setting up the driving speed has a feature that has been existing for quite a long time now. Similarly with the cruise-control systems that control space between the vehicles on the road, allow the vehicle to keep centered in the lane, advanced brake assistance, forward collision warning, a blind-spot monitor as well as parking assistance, where the car does not need a human navigator to fit into a parking space (Krome, 2017).

The Society of Automotive Engineers have developed a five-level classification for the autonomous vehicles:

- Level zero is the group of vehicles without any automation.
- Level one includes vehicles with automated features like adaptive cruise control and lane-keeping systems.
- Level two are vehicles with lateral and longitudinal controls of lane-keeping systems, adaptive cruise-control systems, self-parking systems etc. This is a group of most advanced vehicle systems available commercially.
- If a vehicle had the ability to drive autonomously in some situation (for example in traffic jams or on a highway), it would be classified as level three. These vehicles are not commercially available yet.
- Level four is the category reserved for highly automated vehicles capable of handling independently complex driving tasks but only in strictly defined environment, for example warehouses, manufacturing centers, closed and dedicated lanes on a freeway.
- Completely autonomous vehicle able to navigate in a safe manner in each situation and each environment belongs to level five (Shladover, 2016).

Currently available Tesla cars are equipped with intelligent systems that gives the vehicles the ability to drive fully autonomous. According to Tesla their technology guarantees more safety for the drivers, than a car controlled by a person. The problem to fully launch the autonomous vehicles is the legislation, that does not allow them on the roads anywhere in the world (Nevada, US is the closest to allow self-driving cars). Anyway there are some autonomous functionalities that may be used:

- Enhanced Autopilot: the vehicle can adjust the speed to the conditions on the road, automatically maintain in the center of the lane, autonomously change lanes, self-park when close to the parking spot as well as independently park in the garage and leave the garage.
- On-ramp to Off-ramp is a functionality that allows the car to decide, on which lane the car needs to be to reach the destination. It can also suggest changing the lane to get to the destination faster (Tesla, 2017).

2.4.4 Autonomous vehicles technology

The intelligent technology that enables the autonomy of vehicles is a complex system combining many different mechanisms and components: tools to recognize the surrounding like radars, laser lights, GPS, odometry, computer vision, sensors, as well as advanced software to gather, analyze and store the data, that is also able to “learn”. The following paragraph presents Google’s self driving car (Waymo) equipped with technology that makes it possible to automate the driving tasks.

2.4.4.1 Lidar

The most powerful device in a Google’s autonomous vehicle is Lidar - the rotating camera mounted on the top of the vehicle’s roof. Lidar is a laser range finder with the array of 64 laser beams. In order to enable the navigation, the device develops digital 3D images of objects around the vehicle. Based on bouncing a laser beam off of objects around the vehicle Lidar determines the distance and the spatial structure of surrounding objects. It uses a Velodyne 64-beam laser that can perform exact measurements within 200 meters range. Lidar resembles a radar system but the technology is way more complex. The advantage of Lidar is the 360 degrees field of view as well as the capability of recognizing objects on the curves. Nevertheless it is cooperating with radar systems to develop a reliable, robust, real-time applications and allow the system to deliver a secure driving experience. Waymo is not the first project to use Lidar technology though. It has been used before to develop high resolution maps applied in science like geodesy, geomatics, archeology, geology, seismology, atmospheric physics and more (Clark, 2015).

2.4.4.2 High-powered cameras

Waymo has one or more cameras mounted on the top of the windshield, which mimic the driver’s eyes and allow the car to actually “see” objects on the road - both moving ones like pedestrians, other vehicles, cyclist as well as non-moving obstacles like barriers and road signs, traffic lights etc. The cameras allow the car to study the surroundings, understand and interpret the signs on the road. Waymo’s sight width is 50 degrees and the accuracy is 30 meters. The cameras are mounted with a separation so that they create an overlapping view of the exterior, just like human’s eyes (Clark, 2015).

The technology used to build the cameras has the source in the knowledge human eye. An eye delivers the signal with overlapping images to the brain to enable the determination of depth, peripheral motion and dimensionality of objects. This ability is called stereopsis.

Another characteristics is the fact that for many animals the eyes are located in different positions on the horizontal line, which allows the brain to combine two images projected to the retinas. Thes images are slightly different, which is called horizontal disparity or binocular disparity. The visual cortex in the brain processes these images and helps to the depth and three-dimensionality of the sight (Howard & Rogers, 1996).

2.4.4.3 Radars

The radars play the main role in speed assessment. There are four radars enabling cruise-control systems built in on the bumpers in the front and rear of Waymo. The radars in the front of the vehicle also “recognizes” the vehicles ahead and keeps a safe distance of 2-4 seconds. Thanks to this technology the car can adjust the speed and other variables to the behaviour of other cars on the road (Clark, 2015).

2.4.4.4 Positioning

Each autonomous car is equipped in advanced positioning systems. Waymo has an aerial mounted in the rear, which communicates with the GPS satellites and enables the reception of exact location data. The GPS data is also compared and verified with the sensor data collected for a particular location to maximize the accuracy of the surroundings mapping. Using these two sources of data and comparing those against each other Waymo “learns” its environment. These “learnings” are then further compared with the on-board cameras to process the real-time information and increase the precision through adding additional information of new obstacles or other vehicles on the road.

The positioning systems used in self-driving cars technology do not look similar to the standard location maps. The positioning systems contain much more details, which turns out to be a challenge to the growing new technology. Up to May 2017 Google has mapped approximately 2000 miles of road. There are more than 170000 miles of roads only in California and more than 4 million miles in the United States. To ensure safe operation of the autonomous cars, the environment mapping must be carried on continuously which means that the amount of processed data will significantly grow (Clark, 2015).

2.4.4.5 Simultaneous localization and mapping

Development and maintenance of the location mapping has been a priority for the research on autonomous vehicles. The algorithms used here create and maintain a map of the environment and track the agent’s location in this environment simultaneously. The autonomous cars use SLAM algorithms to merge data input from the sensors with the location maps and as a result update the maps with the new information. Another system is DATMO. DATMO enables the detection and tracking of moving objects. The research on the system has been run for many years now and the problem of moving objects is quite complex. The moving items are of various kinds - people, animals of different size, color, shape, bicycles, motorbikes, wheelchairs, cars, trucks, busses etc. They motion pattern is different - from regular to not-regular, from very slow (an elderly pedestrian) to fast motorcycles. Waymo team has improved the DATMO algorithm to make it as reliable as possible in crowded urban areas.

Any self-driving vehicle moving in a busy environment full of both stationary and moving objects requires more than just good working SLAM or DATMO system in isolation. The Waymo team developed a mathematical framework for both of the algorithms to work together and it is proven that the combination of both algorithms is superior to one system only. Scientists at Carnegie Mellon University have been working on the location positioning of the autonomous vehicles - the vehicles "knowledge" about every single object in its surroundings - both stationary and moving - would improve the precision of the predictions about the future and increase the effectiveness of the decision taking process.

2.4.5 Continuous research on autonomous vehicles

Science advocates the view, that autonomous vehicles will be safer than human drivers, but until the technology reaches that point the machines still need to "learn" from people. Richard Grey as well as other experts from Mailonline believe, accidents involving self-driving vehicles will happen but the technology will improve rapidly - also "learning" from the incidents and malfunctions. Joshua Brown is a victim of an unfortunate accident caused by the Autopilot of Tesla Model S. The collision of the self-driving Tesla with a truck was caused by its radars, that did not distinguish the white trailer from the clouds. Tesla should not drive fully autonomously as of now, so the Autopilot is supposed to be a support for a human driver, but according to Google experts, partial involvement of a driver is not an effective solution. It is difficult for a driver that is supposed to control an autonomous vehicle to keep focus and not get distracted easily. In order to prevent tragical accidents of self-driving vehicles in the future companies like Jaguar Land Rover, Bosch and the Transport Research Laboratory started a project called Move-UK. The project aims on identifying the way the computers in self-driving cars gather information about risk and react to it. Move-UK installs sensors in autonomous vehicles, that are then driven by human drivers. The sensors collect data on the risk and the decisions taken by the drivers and continuously "learn" how to react better (Grey, 2016).

Michael Wagner - a robotics scientist at Carnegie Mellon University in Pittsburgh - is a well known scientists in the field of autonomous car research. Wagner works for Uber and has been testing the self-driving vehicle for the past months driving around the city and gathering information about the surroundings. The law does not allow autonomous vehicles to drive on their own so all tests include a human driver controlling the vehicle in case the computer does not react properly. Uber also had offered taxi services to people until the fatal accident in Arizona, when a pedestrian died after being hit by the self-driving car (della Cava, 2018).

According to Keith Naughton from Bloomberg, on the roads, the autonomous age is moving from the future into the present. The accident in Arizona happened even before the federal government has decided on the rules for self-driving cars. Anyway the White House approved a measure that would allow thousands of self-driving cars to hit the road until federal regulators have worked out all safety standards. All signs show, the tragedy will not stop the development of this intelligent technology (Naughton, 2018).

3. Research method

3.1 Introduction

The area of research is the influence of Artificial Intelligence on the employment, especially in the Transportation and Logistics vertical. The previous paragraph proves, that intelligent technologies have great potential to influence the processes in Transportation and Logistics as well as the employment structure. To support the thesis the author conducted a research of macro- and micro-economic conditions as well demography and employment structure in the recent years in Poland and Ireland. This chapter explains the research method that was used to support the research questions.

3.2 Purpose of Research

The purpose of this research study is to evaluate the following topics:

- The impact of demography on the usage of new technologies
- The impact of economic growth on the Transportation and Logistics vertical.
- The impact of Artificial Intelligence on the employment structure in transportation and logistics.

The author's intention is to provide insight into the landscape of the economic growth of Transportation and Logistics vertical and the situation on the job market. This research project requires data gathered on a national and international level, so the author decided to use secondary data as the source to answer the research questions.

3.3 Research Philosophy

According to Saunders, Lewis and Thornhill the research philosophy explains the “development of knowledge and the nature of that knowledge”, it includes the researchers belief about how to perceive the topic of research and its environment (Saunders, Lewis, and Thornhill, 2009). The authors distinguish 3 major options of research philosophy: epistemology, ontology and axiology. This paper focuses on epistemology, which is the philosophy that answers the question about what makes certain knowledge acceptable in a field of study. Epistemology discusses the feasibility of answering a research question in the way defined by the researcher (Saunders, Lewis, and Thornhill, 2009).

There are four research philosophies that belong to epistemology: pragmatism, positivism, realism, interpretivism.

3.3.1 Pragmatism

The research philosophy called pragmatism ultimately aims on action. This philosophy recognises many different methods of gathering data analyzing and interpreting it and there is no one recipe that would work for different types of research. It is also impossible to picture the world with a single point of view and there is an indefinite number of questions that can be asked to answer one research query (Saunders, Lewis, and Thornhill, 2009). According to Shramaatit Moksha pragmatic research philosophy pictures a research approach that uses mixed methods - it is acceptable for the researcher to use different strategies of collecting, analyzing and interpreting data to answer the research question. Pragmatism allows researchers to use both quantitative and qualitative methods in a subjective and objective approach, as long as the chosen method would lead to satisfying result (Moksha, 2013).

3.3.2 Positivism

Positivism is a research philosophy that affirms the idea of purely scientific approach being the only method appropriate to learn the truth about the world. Positivistic approach to the research requires the knowledge about facts and the researcher plays the role of the collector, analyst and objective interpreter of the measurable data. Positivist philosophy leads to quantifiable observations based on an analysis carried out in a statistical way.

John Dudovskiy lists five main positivist principles in his article:

“1. There are no differences in the logic of inquiry across sciences.
2. The research should aim to explain and predict.
3. Research should be empirically observable via human senses. Inductive reasoning should be used to develop statements (hypotheses) to be tested during the research process.
4. Science is not the same as the common sense. The common sense should not be allowed to bias the research findings.
5. Science must be value-free and it should be judged only by logic” (Dudovskiy, 2018).

3.3.3 Realism

According to the research philosophy called realism the reality is independent from human mind. There is direct realism and critical realism. Direct realism is also called naive realism because the researcher believes their senses. This philosophy allows defining the world in a completely subjective way, from the point of view of the researcher. Critical realism on the other side argues with the validity of the researchers perception. The subjectivity of the researcher can not portray the truth picture of the world.

3.3.4 Interpretivism

Interpretive research philosophy believes that “access to reality (given or socially constructed) is only through social constructions such as language, consciousness, shared meanings, and instruments” (Myers, 2008). Interpretivism criticises positivism through focusing on qualitative research instead of quantitative research.

3.4 Research Strategy

This main strategy for the research conducted for this dissertation is the positivism. The author analyses quantitative data derived from secondary sources and draws conclusions based on them.

3.5 Research methodology

A research methodology is a structured framework, that is used by the researcher to conduct the research. The methodology describes, explains and justifies the actions that were taken by the researcher during the research, defines them, puts them in order and standardizes the use of different actions (Saunders, Lewis, and Thornhill, 2009).

The scholars have been trying to define the research methods for many years now and there are different studies on this topic identifying different frameworks. One of the first studies on research methods was conducted by Peritz in 1977 in the dissertation “Research in library science as reflected in the core journals of the profession: A quantitative analysis”. Peritz described 11 research methods. Hildreth and Aytac in “Recent library practitioner research: A methodological analysis and critique” described research methods that are well known by current scholars and broadly used in the recent studies. They distinguish different research types, for example descriptive, exploratory, explanatory, and evaluative, various methods for data collection like survey questionnaire, survey interview as well as data analysis approaches: quantitative and qualitative (Chua and Keb, 2017).

3.5.1 Definition of secondary data research

Secondary research includes gathering, analysis and interpretation of existing data research. Unlike primary research, secondary research does not involve the generation of data. It operates with primary research sources as a source of data for analysis (Library.ithaca.edu, 2018).

The author decided to use secondary data for the research conducted for this dissertation. Secondary data is any data gathered by another person than the person that uses it for their research, whereas primary data is the data collected directly by the researcher. Secondary data can be quantitative or qualitative. Quantitative data is objective and includes measurable, mostly numerical facts and statistics while qualitative data is mostly in the contextual form and includes subjective description of the world. The following research analyzes and interprets quantitative data.

Saunders, Lewis and Thornhill divide secondary data into three groups: documentary, multiple-source and survey data as presented in the table below.

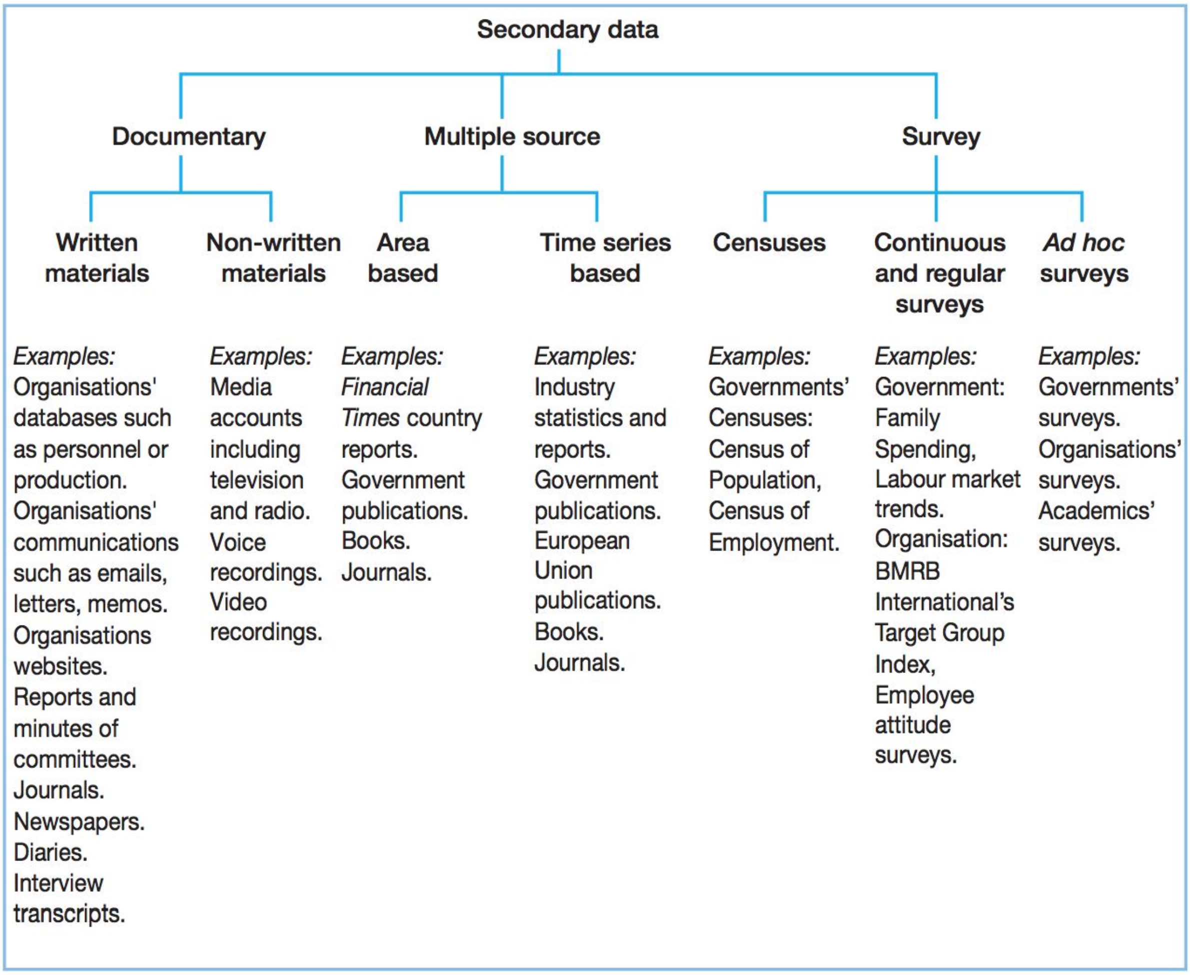

Table 3.1 Secondary data analysis (Saunders, Lewis, and Thornhill, 2009)

The research focuses on survey-based data that was collected in censuses in Poland and Ireland as well as in continuous and regular surveys. These data is usually collected by means of questionnaires, which have been analyzed already for the initial research, however it is available to use by other parties as it is easily accessible, available in data tables or a matrix of raw data that can be downloaded for the secondary analysis (Saunders, Lewis, and Thornhill, 2009). When it comes to the way of data collection the authors distinguish censuses, regular surveys and ad hoc surveys. Censuses are a strong source of data because the data is collected by governments for socio-economic analysis of the society and the these surveys are obligatory. They offer great coverage of the population, is well defined, documented and of highest quality. Censuses often provide great archives going back to the 18th century. Regular surveys are surveys carried out by professional organizations that repeat regularly (Saunders, Lewis, and Thornhill, 2009). Censuses and continuous survey data were used for the research in this dissertation to provide insights into the socio-economic areas of the research.

3.5.1.1 Advantages of secondary research

Thanks to the technological advancement researchers have easy access to great amount of data. Secondary data research got more popular as this method provides great flexibility and the data can be used in several different ways. Secondary data research gives the researcher the opportunity to create new connections. It allows the comparison and cross-analysis of different sets of data and allows the search for deeper meaning than the one derived during the primary research (Tantawi, 2013).

The use of secondary data is more cost effective and less time consuming than primary data collection and analysis. Often the researcher would not be able to afford a data collection and analysis on a scale and scope in time and space as large as when they access secondary data. For example Census records provide data on the whole population of the country several decades or even centuries in the past. Using the example of Census, the secondary research may be the only available source of data.

The access to secondary data creates broad opportunities for all researchers - also the novice ones that do not get significant financial support for their studies. It equalizes opportunities and creates more capacity for research, which can broaden and deepen the general scope of research in particular field. For the research of areas like information and technology the speed of research is crucial. These areas are constantly changing so saving the researchers time through utilizing existing data allows research projects to be completed mach faster. This allows the quick production of results and fast development of new knowledge. Secondary data analysis also allows replication, re-analysis and re-interpretation of existing results, which creates opportunities to experiment with new ideas with low risk (Johnston, 2014).

3.5.1.2 Limitations of secondary research

Primary data is often the preferred way of conducting the research because it can be tailored for the particular research question. There is no control over the questions that were asked in the survey questionnaires as well as on the sample and targeted group. The secondary data may not address the details that the researchers is searching for or the data may be collected in a way that is not ideal to answer the research question - for example the data was collected in a geographical region that is not the main interest of the secondary study. It also minimizes the probability of unknown bias that might impact the final result. Secondary data research might lead to inaccuracies, because of the possibility of subjective interpretation (Tantawi, 2013). Another disadvantage may be missing documentation of the primary research procedures - this creates issues mostly with qualitative data, where responses may be highly influenced by the way the question was asked or who asked this question. The researcher using secondary data must always account sufficient margin of error and bias.

3.5.2 Process of secondary data research

The process of secondary data research begins with an analysis of the known topics and the questions that remain open based on the research that was conducted before by other researchers. The area of interest of the researcher and the research questions influence the methodology that should be used, which is combined of the way how the data is collected, analyzed and interpreted. Secondary data analysis is conducted in a systematic way with procedural and evaluative steps starting with development of research questions, which are followed by the identification of the dataset and the review and interpretation of the dataset (Johnston, 2014).

3.5.2.1 Develop research questions

To conduct successful research of secondary data it is crucial to define research questions. The research questions allow the researcher to structure their approach to data collection and analysis to maximize the utilization of existing data.

3.5.2.2 Identify and evaluate the dataset

The researcher must find the dataset that lead to answer their research questions and also evaluate if the dataset provides congruence of the primary and secondary study. To prove the congruence the researcher should answer the following questions:

- What was the purpose of the primary study?
- Who was responsible for collecting the information?
- What information was actually gathered?
- When was the information collected?
- How was the information obtained?
- How consistent is the information obtained from one source with information available from other sources?

To answer these questions the researcher should use all documentation about the primary research that is available and make sure none of the answers contradicts the objectivity of their secondary study. The factors like initial purpose, the people collecting the primary data, the time and the way of collecting data may influence the result of the primary study so would not provide an objective foundation for the secondary research.

3.5.2.3 Secondary data research process - summary

Analyzing secondary data provides a broad scope of methodological advantages and offers a great support in drawing new conclusions that contributes to the general knowledge expansion. The goal of a researcher analyzing secondary data is to search for alternative perspectives in order to improve the scientific knowledge. Following the process of secondary analysis of data the researcher relies on the existing datasets and on the previous method to gather these data, but it still requires a systematic approach towards the analysis.

3.6 Secondary data research: sources and methods

As stated in the previous paragraph, the process of secondary data analysis is build out of the following elements:

- Development of research questions
- Identification of dataset
- Review and interpretation of the dataset (Johnston, 2014).

The following paragraph re-introduces the research questions and the hypothesis as well as references the secondary researches that the author used to gather the necessary data and describes their data gathering methodologies.

3.6.1 Research questions

As stated in the first chapter of this dissertation the main research question posted is:

- What is the impact of Artificial Intelligence technologies on the employment in Transportation and Logistics industry in Ireland and Poland?

The author posts also more granular questions that support the main research questions:

- What demographic changes do we observe currently in Poland and Ireland?
- What is the change in the employment structure in general?
- What is the change in the employment structure in Transportation and Logistics?
- How did the salaries change in the recent years in Poland and Ireland?
- Did the change in salaries impact Transportation and Logistics?

3.6.2 Identification of dataset

To answer the demographic as well as economic and social questions the author required bit sets of data regarding the European population as well as Polish and Irish inhabitants.

3.6.2.1 Who was responsible for collecting the information?

There were two main sources that served as the foundation for this research:

- Research gathered by the Organisation for Economic Co-operation and Development (OECD)
- The 2017 Revision of World Population Prospects by United Nations

3.6.2.1.1 Organisation for Economic Co-operation and Development

The Organisation for Economic Co-operation and Development is a forum for 30 democratic countries to work together on economic, social and environmental topics. It also support governments with their challenges coming from their economic development and changes in demography, for example the ageing population. The OECD is a forum where different countries can discuss their experiences and best practices to improve their local policies as well as the cooperation with other governments. The members of OECD are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States (Organization For Economic Co-Operation And Development, 2007).

The goal of OECD is to continuously monitor the world events as well as the events in the member countries. The organization’s focus is the demography as well as macroeconomics and microeconomics and their influence on the governments and international relations. The OECD Secretariat is responsible for the collection and analysis of data, that is then published by the OECD Publishing, which is an organization with the goal of spreading the results of the Organisation’s statistics gathering and research.

The OECD has a great reputation for the coordination and the quality of its statistical program (Oecd.org, 2018). The data is collected directly or indirectly from the official statistics organizations in different countries, which collect data from the largest samples (e.g. Irish Census aims to survey 100% of population) and choose of different survey methods: questionnaires, web queries, online platforms as well as SDMX. The research conducted by the national statistical organizations are often run in collaboration with other organizations like Eurostat or United Nations (Oecd.org, 2018).

3.6.2.1.2 2017 Revision of World Population Prospects by UN

The United Nations organization has established the Population Division to play the role of the Secretariat of the Population Commission (built in 1946). The Population Division has led the international discussion on population and development for many years. It has regularly produced high quality demographic information and prognosis and supported governments with their demographic challenges and questions.

The 2017 Revision of World Population Prospects published by the of the Department of Economic and Social Affairs of the United Nations Secretariat is the twenty-fifth edition of the population estimates and projections. It presentes the key demographic indicators for different countries and different demographic groups within these countries. The time frame that the 2017 Revision of World Population Prospects look at is from 1950 to 2100 (Esa.un.org, 2018).

3.6.2.1.2.1 Poland

The data gathered, analysed and presented by “The 2017 Revision of World Population Prospects” as well as by OECD informing about Polish population comes from multiple research sources. The main one is the Polish Cenzus 2011.

3.6.2.1.2.2 Ireland

The main source for the information about Irish population used by “The 2017 Revision of World Population Prospects” and OECD is the Census of Ireland 2016. The census in Ireland is run by the Central Statistics Office (CSO), which is an independent statistics organization established in 1949 and, according to the official website www.census.ie, “operating under the aegis of the Department of the Taoiseach to guarantee its statistical independence and the confidentiality of the data it collects” (Census.ie, 2018).

3.6.2.2 What was the purpose of the primary studies?

3.6.2.2.1 Polish Census 2011

The Polish Census is the main source of details on the Polish population - its demographic, sociological, professional and economical structure. It also informs about the Polish households and families. The main goal to run the census is to obtain reliable and detailed data on the country statistics, which then serve as the foundation to run further research. The census in 2011 focused on the demographic changes in the Polish society after the country joined European Union. The research also wanted to analyze trends and run comparative analysis based on the data from the previous census in 2006 (Stat.gov.pl, 2018).

3.6.2.2.2 Irish Census 2016

The census is the research that gives a comprehensive picture of the demographic and economic situation of the Irish society. The results of the census are the foundation to run effective policy as well as conduct thorough planning and take decisions for the Irish population regarding different topics, for example health care, education, employment management etc. The history of Irish Census goes back to the year 1821, when the first census was conducted. The research allows the Irish statistics organizations to observe developments over a long period of time with high accuracy. According to the official census website www.census.ie the research is “a fundamental part of our national heritage and collective knowledge” (Census.ie, 2018).

3.6.2.3 What information was actually gathered?

3.6.2.3.1 Polish Census 2011

The following topics have been the focus of the Polish Census 2011:

- Demographic characteristics of the population
- Education
- Economic activity of the population
- Commuting
- Sources of income
- Disabilities
- Citizenship
- Internal migrations
- International migrations
- Nationality and language as well as national and ethnic minorities
- Religion
- Families and households
- Housing conditions (Stat.gov.pl, 2018).

3.6.2.3.2 Irish Census 2016

The Irish Census 2016 contained 35 questions on the form, which must be answered by each individual person in the household. The topics of the questions are as follows:

- Housing in Ireland
- Population Distribution and Movements
- An Age Profile of Ireland
- Households and Families
- Homeless Persons in Ireland
- Commuting in Ireland
- Migration and Diversity
- Irish Travellers, Ethnicity and Religion
- Health, Disability and Carers
- Education, Skills and the Irish Language
- Employment, Occupations and Industry (Central Statistics Office, 2018).

3.6.2.4 When was the information collected?

3.6.2.4.1 Polish Census 2011

The data for Polish Census 2011 was gathered from the 1st April 2011 to 30th June 2011 (Stat.gov.pl, 2018).

3.6.2.4.2 Irish Census

Every Irish inhabitant present in Ireland on Sunday 24 April 2016 had the duty to fill in the census survey. Enumerators delivered census forms to every household in the country in the weeks before the census day, and visited the households to collect the forms in the 3 weeks after census night (Census.ie, 2018).

3.6.2.5 How was the information obtained?

3.6.2.5.1 Polish Census 2011

In the Polish Census 2011 the data was gathered by using the mixed survey method - it used the informatic systems of the public administration as well as the data gathered in the full and representative research study in the following order:

1) Collection of data from the informatic systems
2) Online acceptance or correction of the personal data collected by the informatic systems
3) Phone interview run by a poller from the statistics office (CATI)

4) Personal interview (CAPI) (Stat.gov.pl, 2018).

3.6.2.5.2 Irish Census 2016

The method of the conduction of the Irish Census 2016 is called a “traditional” census. In this method all individuals are registered directly and the data about them is collected through a census form. The information is gathered in the field at the same time across the whole country. In Ireland the census forms are delivered and collected by designated census enumerators and filled by the individuals in the households (Valente, 2010).

4. Analysis and Findings

4.1 Introduction

This chapter presents the research, that was conducted to answer the main research question of this dissertation, which is What is the impact of Artificial Intelligence technologies on the employment in Transportation & Logistics industry in Ireland and Poland.

4.2 Hypothesis

The hypothesis, that the author is proving with the following research, is that Artificial Intelligence has in fact great impact on the employment in Transportation and Logistics industry in Ireland and Poland, however it does not cause any shrink of the labour demand nor unemployment in any of the countries.

Artificial Intelligence and the development of automation technologies allow the rapid economic growth in societies where the population keeps ageing and the demand for goods and services does not decrease. The Polish economy speeds up and the labour demand is currently larger than the labour supply. In this situation implementation of modern, intelligent technologies and automation of repetitive work tasks increases the efficiency of the Transportation and Logistics sector and supports the closure of the gap between the supply and demand of workforce in Transportation and Logistics.

4.3 Data Analysis

4.3.1 Demographic structure

4.3.1.1 World demographic structure

4.3.1.1.1 Population growth

According to the results of the 2017 Revision of the World Population Prospects published by United Nations (2017) the population in the world reached 7.6 billion in 2017, which means that the world population grew by one billion people in the past twelve years. The most populated region globally is Asia, which is the home for 60% of world's population (4.5 billion). 742 million people live in Europe and this is 10% of the world population. China and India are the most populous countries - 1.4 billion people live in China and 1.3 in India. In general the world's population keeps growing 1.1% per year, comparing to 1.24% per year ten years ago. More than half of the expected population increase is going to happen in African countries, which will grow by 1.3 billion by 2050 (Esa.un.org, 2018).

4.3.1.1.2 Decrease in fertility

Europe is going to be the only continent with a smaller population in 2050 than in 2017 (2017 revision key findings). There are several countries on the European continent where the population will decline by more than 15% - Bulgaria, Croatia, Latvia, Lithuania, Poland, Republic of Moldova, Romania, Serbia, Ukraine and the United States Virgin Islands. The reason for the population decrease is the drop in fertility. According to the Glossary of Demographic Terms by United Nations - DESA / Population Division the definition of fertility is:

"The average number of live births a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as live births per woman" (Esa.un.org, 2018).

In Europe the fertility rate is below the level that is necessary for the replacement of the population in the long run. To keep the population stable the fertility should be around 2.1 births per woman. In the countries mentioned above this metric has been lower than 2.1 children per woman for several decades.

4.3.1.1.3 Increase in longevity

The 2017 Revisions by United Nations makes also projections regarding the life expectancy, which is defined as "the average number of years of life expected by a hypothetical cohort of individuals who would be subject during all their lives to the mortality rates of a given period" (Esa.un.org, 2018). The life expectancy has risen around the world in the recent years with the most rapid growth in Africa and a steady growth in other continents - also Europe. In total the expected life length grew by 3.6 years from 2000 - 2005 to 2010 - 2015 and achieves 77.2 in Europe in 2017.

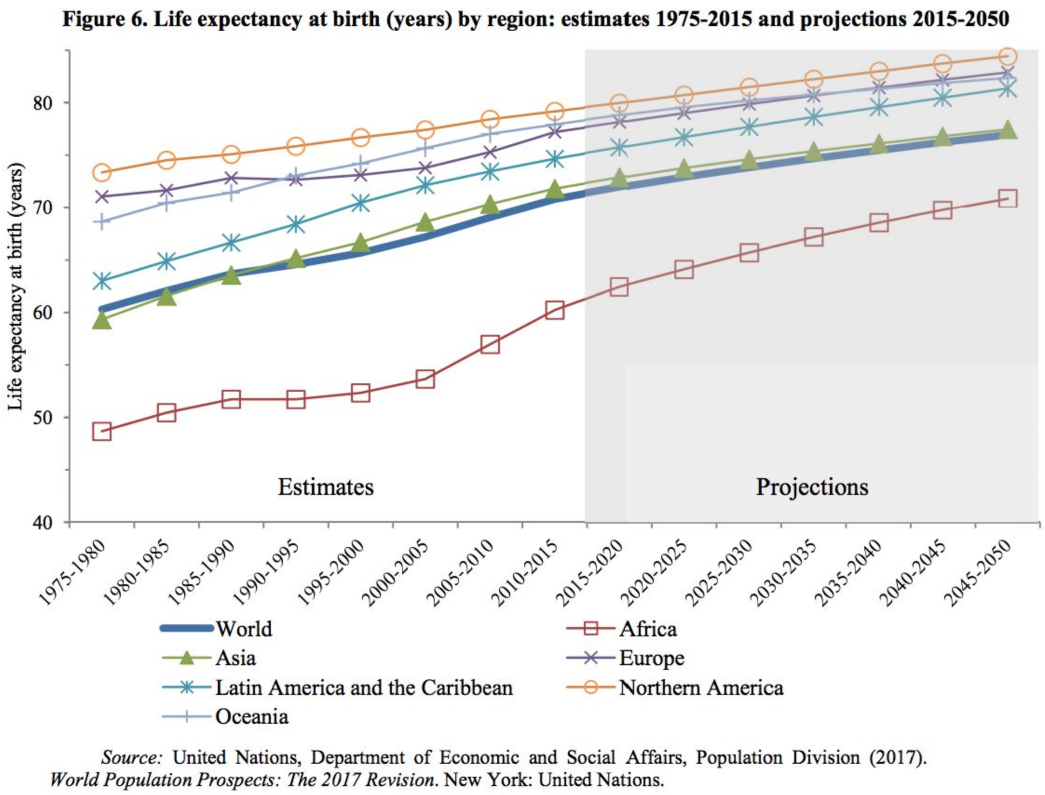

Figure 4.1 Life expectancy at birth by region: estimates 1975-2015 and projections 2015-2050 (Esa.un.org, 2018)

4.3.1.1.4 Ageing population

As the life expectancy keeps growing and the fertility declines globally the world experiences the situation of a stable growth of the population aged 60 or more. This age group is growing faster than all younger age groups. This phenomenon is called population ageing and is occurring in all continents besides Africa. There were 962 million people aged 60 or more in 2017, which is 13% of the world's inhabitants. This number is projected to grow at a rate of around 3% annually. The greatest share of older population is in Europe (25%). The research projects that by 2030 there will be 1.4 billion people over 60 year old in the world, by 2050 2.1 billion and 3.1 billion by 2100. There is a big probability that the projections will come to terms, which is proven by the small size of the cohorts born in the recent years (Esa.un.org, 2018).

4.3.1.2 Poland and Ireland

4.3.1.2.1 Population

The research conducted by the Department of Economic and Social Affairs of United Nations projects the population of Poland to decrease until 2010. The size of the Polish population kept growing until the year 2000 which was caused by the significant political changes in the Polish country followed by the increase in the wealth of the society and the notable rise in the living standard in Poland. However around the year 2000 we started noticing a drop in the size of the inhabitants of Poland, which is expected to continue for the next nine decades. The situation is slightly different in Ireland, where the population keeps growing slightly from 1950 until 2100 (Esa.un.org, 2018)

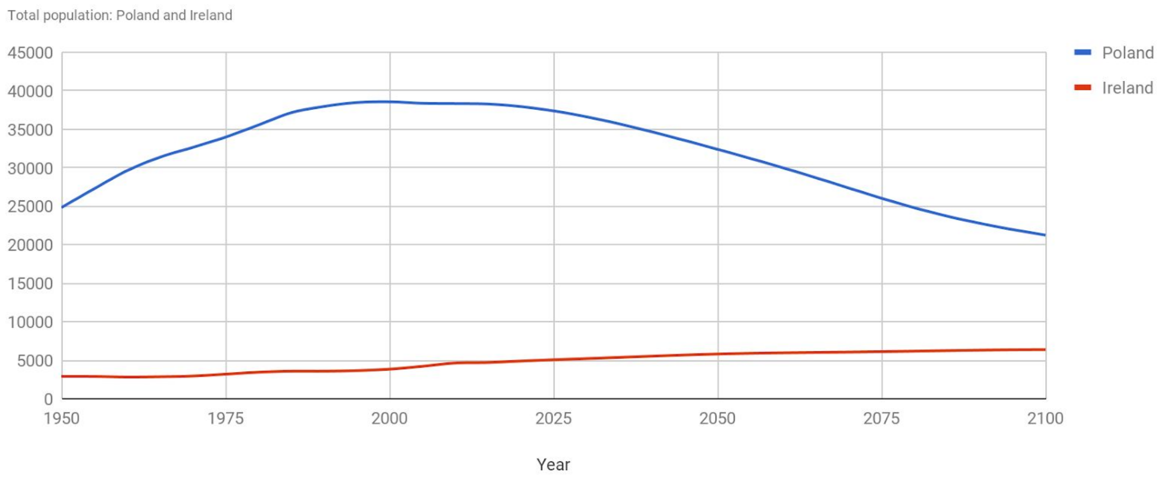

Figure 4.2 Total population: Poland and Ireland

4.3.1.2.2 Ageing population

4.3.1.2.2.1 Fertility

Similar to the majority of European countries, the fertility in Poland is expected to be smaller than the necessary 2.1 births per woman to keep the size of the population stable. The fertility rate in Poland was 3.63 straight after the second world war, which was the highest level since the beginning of the 20th century. The number of children per one women reached the depth of 1.26 in the years 2000 - 2005 and is projected to slightly grow until

2100. Nevertheless the growth will not guarantee the stable size of the population, therefore we are likely to observe the size of the Polish society to decline.

When it comes to Ireland, the number of children per one woman reached the height of more than 4 in the second decade after the second world war in the years 1960 - 1965 and was high at the range close to 4 over the next 10 years until 1975. Since the year 1975 we can observe a significant drop in fertility, that was caused by the introduction of the modern lifestyle, when the family model 2+2 became the most popular one. Irish fertility rate has been stable at the level around 2 since 1995 and is not expected to change dramatically over the next 80 years. Similar to Poland, the rate is not enough to ensure the growth of the size of the Irish population (Esa.un.org, 2018).

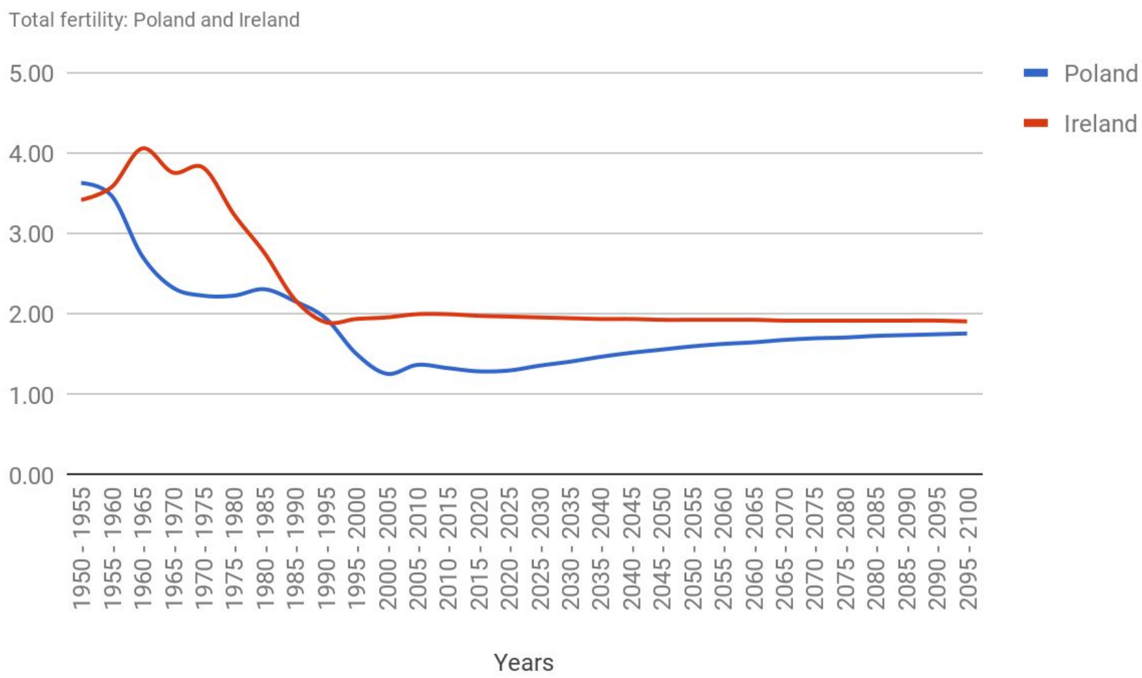

Figure 4.3 Total fertility: Poland and Ireland

4.3.1.2.2.2 Rate of natural increase

Following the Glossary created by the United Nations, DESA / Population Division to accompany the World Population Prospects (2017) The rate of natural increase is defined as “crude birth rate minus the crude death rate”. The natural increase rate “represents the portion of population growth (or decline) determined exclusively by births and deaths” (Esa.un.org, 2018).

The rate of natural increase in the whole Europe has been below zero since the beginning of the 21st century and is projected to be around -3% until 2100. Poland has one of the lowest rates of natural increase in Europe. It was around zero in the years 2000 - 2005 and dropped to the negative values since 2005. It is steadily declining and is projected to reach the dip of -9.6% in the years 2070 - 2075. The metric is relatively positive in Ireland. It reached the highest level of 12% in 1975 - 1980. The following years showed a slight decline but the rate grew to 9.8% again in 2005 - 2010. The rate of natural increase will be positive in Ireland until 2100 however it is expected to be less than 1% starting in the year 2055.

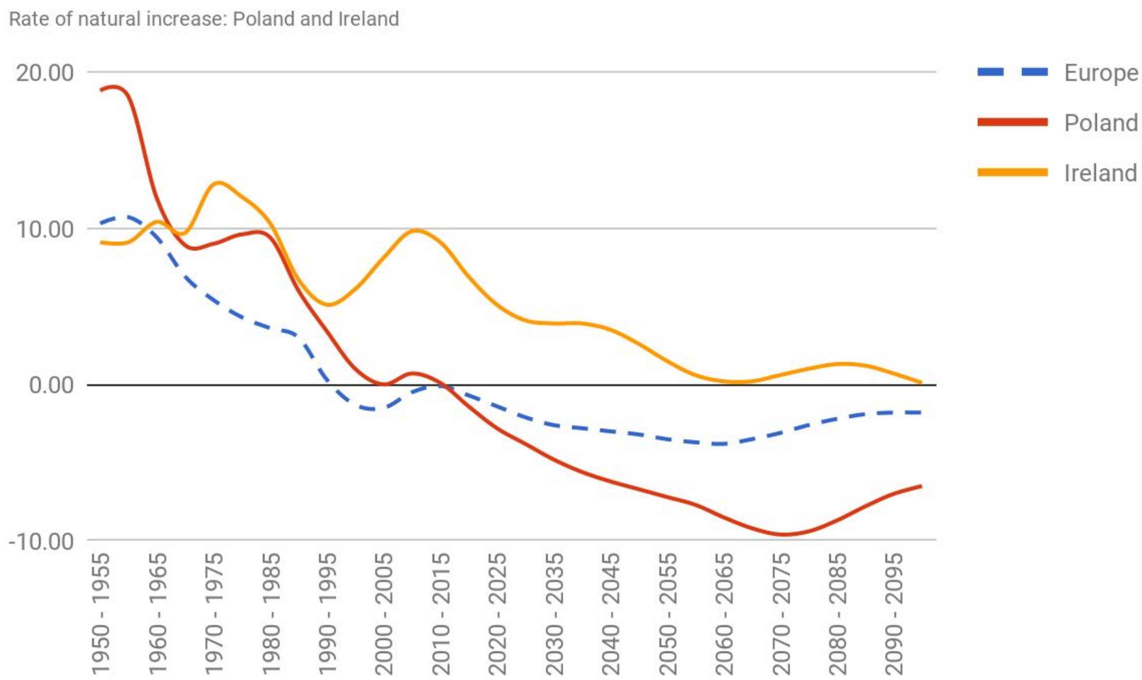

Figure 4.4 Rate of natural increase: Poland and Ireland

The fertility rate on a level below 2.1 births per woman and the low natural increase in Poland cause a change in the population structure when it comes to the age. The Polish population is and will continue to be an ageing population and the number of people older than 65 years old is projected to grow significantly until 2060.

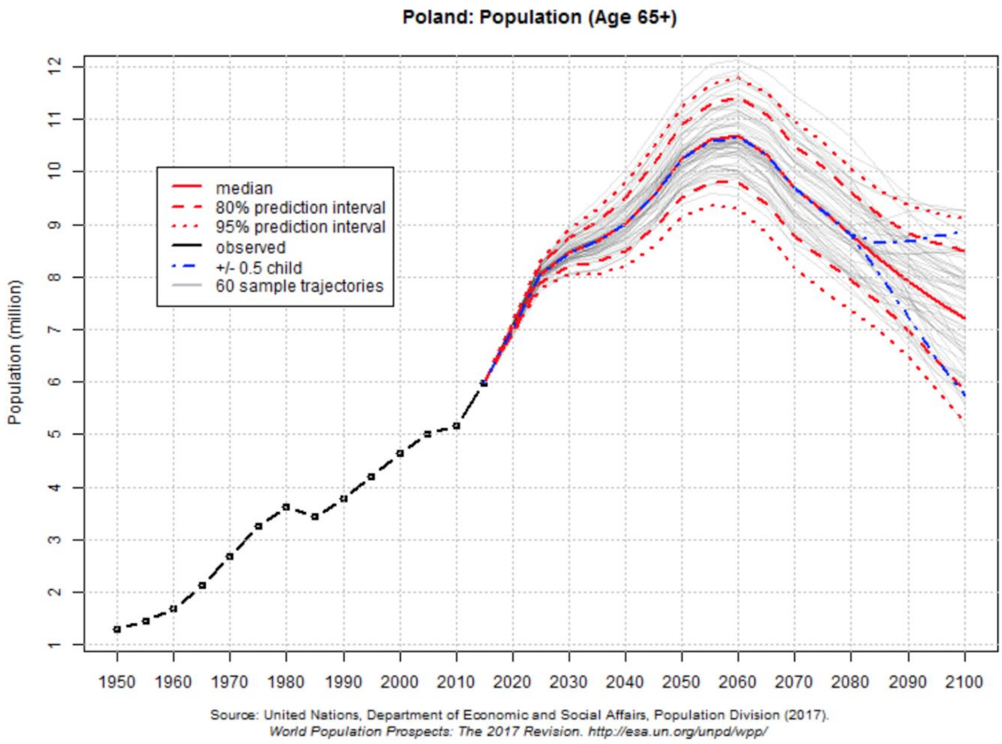

Figure 4.5 Poland: Population (Age 65+)

The situation is similar in Ireland. The population of people aged more than 65 will be the largest in 2050, however the growth was slower than in Poland until 2010 and will accelerate in the upcoming 3 decades (Esa.un.org, 2018).

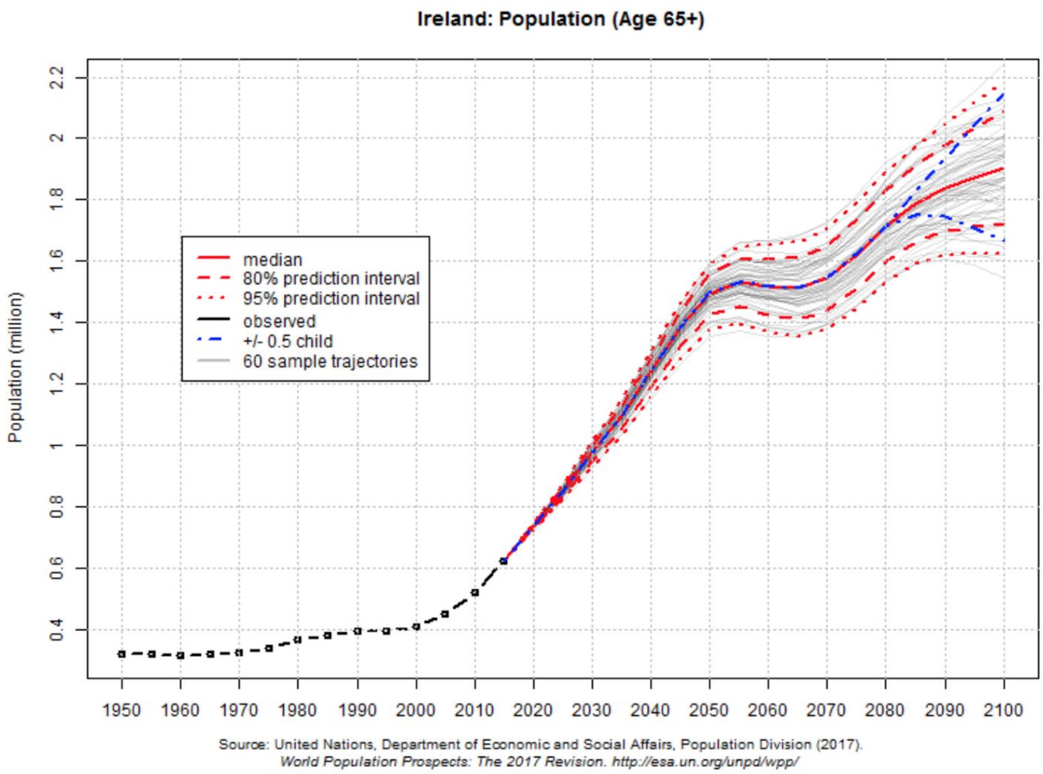

Figure 4.6 Ireland: Population (Age 65+)

4.3.1.2.2.3 Working age population vs. elderly population

OECD defines working age population as the population between 15 and 64 years old. This is the part of the population that is actively working and positively supporting the fiscal system of the countries with their taxes. The proportion of the working age population to the employed population is the measure for employment and unemployment rates and the ratio of working age population to the non-working age population gives a picture of the demographic structure of the society (OECD, 2018).

When it comes to the elderly population OECD defines it as the part of the population aged 65 and over. Another measure is the elderly dependency rate, which is the proportion of the population aged 65+ to the population at the working age (15 - 64 years old). The elderly dependency rate has different implications for the governments and the countries budget. The higher the dependency rate, the larger share of the budget must be allocated to pensions, healthcare etc.

The ratio of the elderly population to the working age population in Europe was relatively stable until 1960 and started to grow afterwards. The projections show that the share of the elderly population will be larger year by year, reach 20% by 2025 and grow up to 30% in 2100.

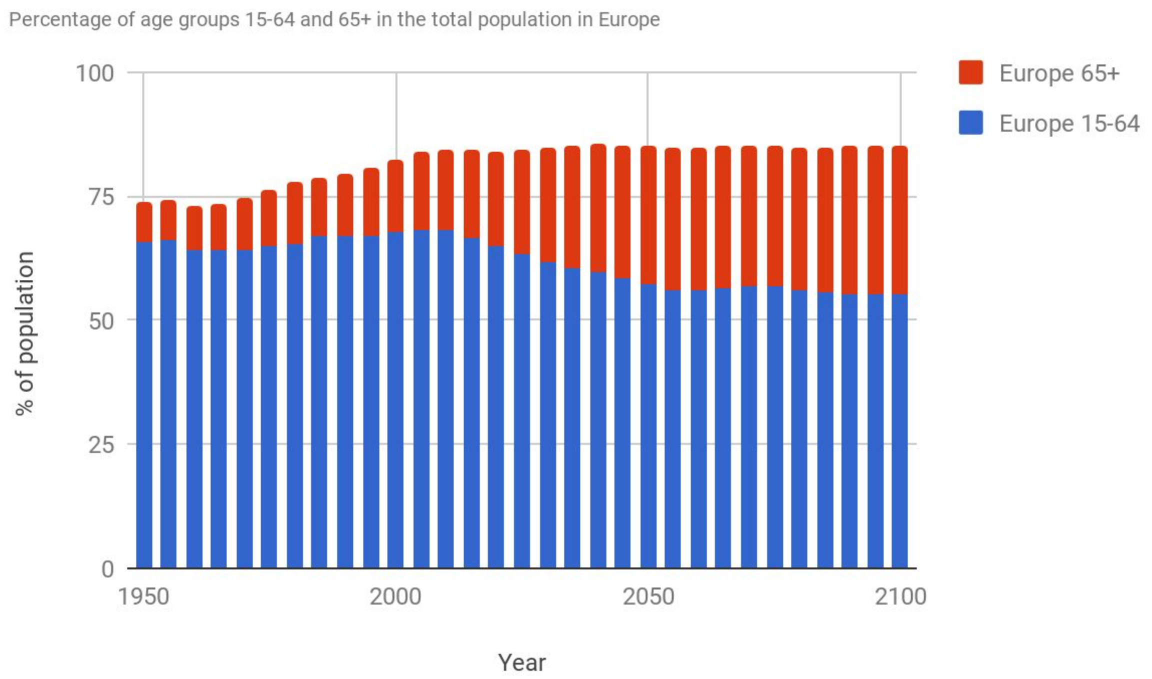

Figure 4.7 Percentage of age groups 15-64 and 65+ in the total population in Europe

The share of elderly population in Poland was lower than 10% until 1980. For the next two decades the ratio was stable and started growing again after 2000. The growth in the upcoming years will be rapid and the ratio will reach 20% by 2025 and 30% by 2050 - 50 years earlier than in Europe. By 2100 the percentage of elderly population in Poland will be 4 percentage points higher than the European rate.

Together with the rise in elderly population the working age population keeps dropping and is projected to drop from 71.3% in 2010 to less than 60% in 2050 and 52.8% in 2100. By 2100 only half of the Polish population will be actively working and supporting the countries budget.

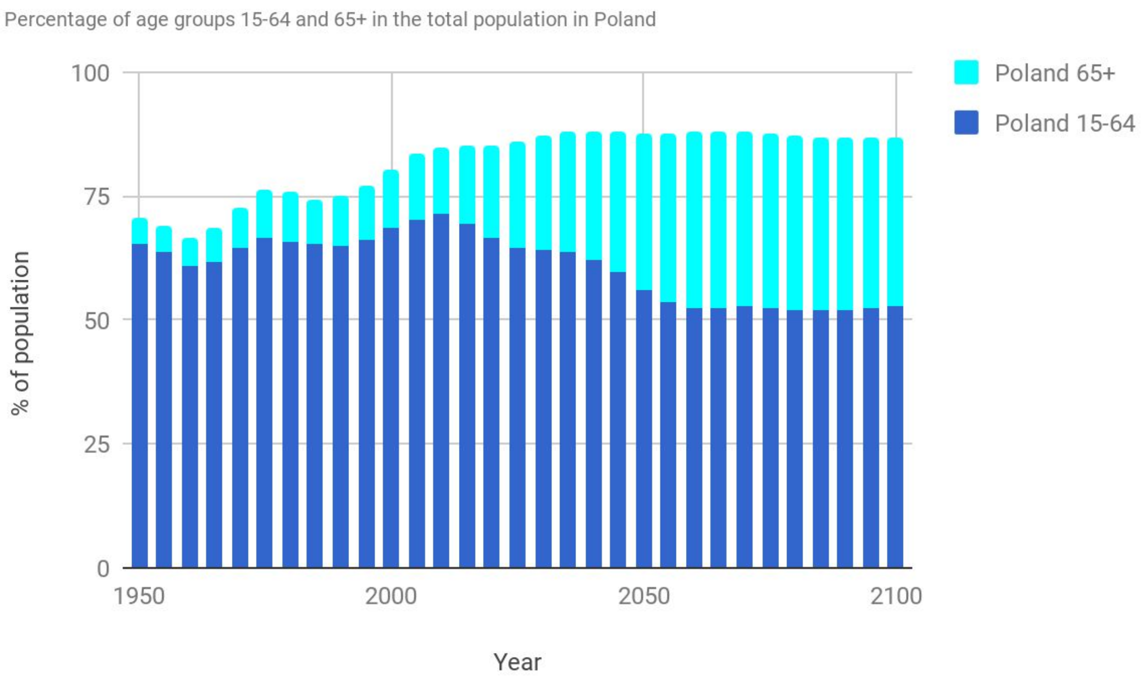

Figure 4.8 Percentage of age groups 15-64 and 65+ in the total population in Poland

The ratio of elderly population in Ireland is very similar to the European ratios. It has been growing since the year 2005 and is projected to reach 20% by 2035 and almost 30% by 2100. The working age population has been declining since 2005. In 2005 the share of working population was 69.2% and started decreasing. The decrease is relatively rapid and the share of working age population is projected to be around 55% by 2100, which is the same as European share (OECD, 2018).

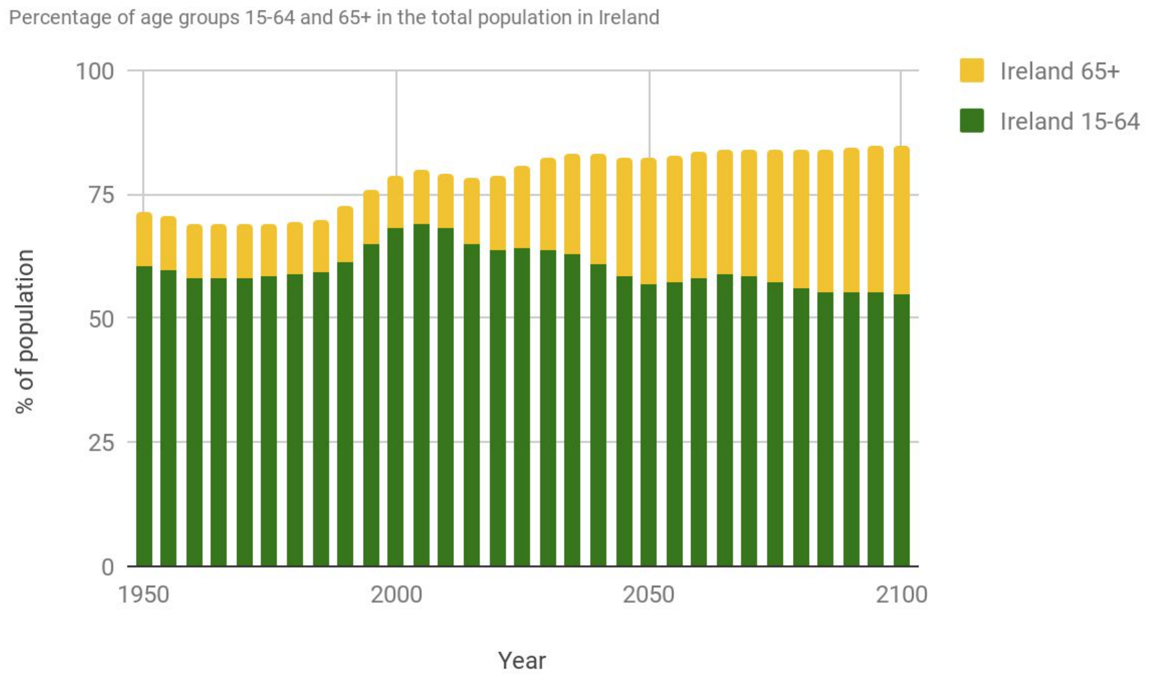

Figure 4.8 Percentage of age groups 15-64 and 65+ in the total population in Ireland

4.3.2 Population wealth

4.3.2.1 Average wage

The wealth of the population can be measured using the average wage metric. According to the OECD, "average wages are obtained by dividing the national-accounts-based total wage bill by the average number of employees in the total economy, which is then multiplied by the ratio of the average usual weekly hours per full-time employee to the average usually weekly hours for all employees" (OECD, 2018).

4.3.2.1.1 Poland

We can observe a rapid growth of the average annual wage in Poland. Since the year 2000 the wages rose by 29.3% from 9,400 USD in 2000 to 12,154 USD in 2016. Nevertheless, the the average annual wages Poland stay behind the most European countries (OECD, 2018).

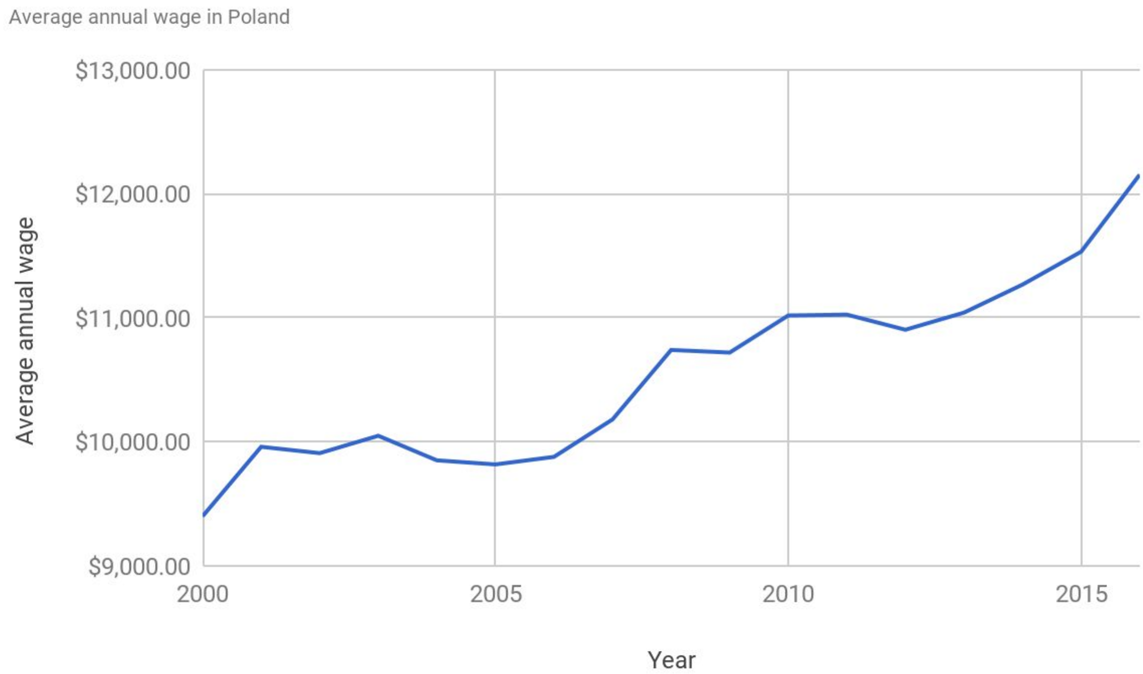

Figure 4.9 Average annual wage in Poland

4.3.2.2.2 Ireland

Similar to Poland, Ireland has experienced a rapid growth of annual average wages too. The wages increased from 43,374 USD in 2000 to 56,787 USD in 2016, which accounts for a 31% increase. Ireland is in the top four European countries with the highest annual average wages - just behind Luxembourg, Netherlands and Denmark (OECD, 2018).

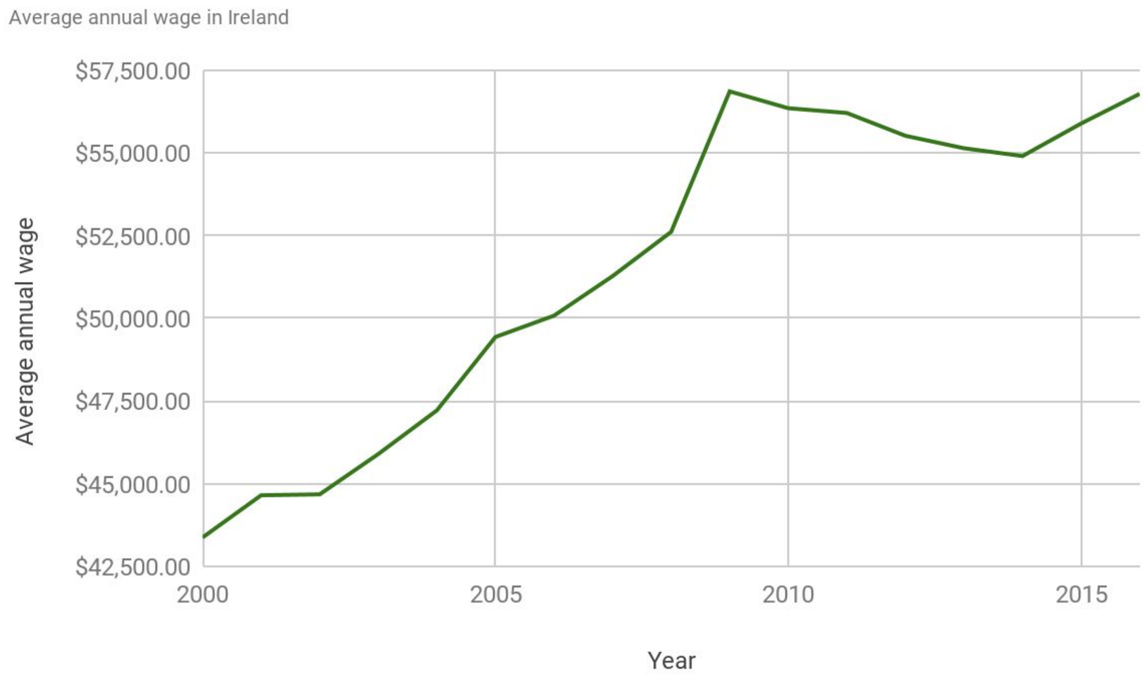

Figure 4.9 Average annual wage in Ireland

4.3.2.3 GDP per capita

According to OECD "Gross Domestic Product is the expenditure on final goods and services minus imports: final consumption expenditures, gross capital formation, and exports less imports" (OECD, 2018). Kimberly Amadeo in her article "GDP Per Capita with its Formula and Country Comparisons" defines GDP per capita as a quantified explanation of a country's economic situation in relation to the number of inhabitants in this country. The metric GDP per capita "divides the country's gross domestic product by its total population" (Amadeo, 2018). As stated by Amadeo, GDP per capita is the best way to measure the standard of living in a country as it presents the prosperity of a country to each citizen.

4.3.2.3.1 Poland

GDP per capita in Poland has been growing rapidly since 1990 and mirrors the political transformation into democracy. Starting at the level of 9,976 USD in 1990 it achieved 26,085 in 2017. We can observe a steady growth of at least 1.3% year over year, however the Polish economy is still far behind other European economies and only before Bulgaria, Romania, Croatia, Latvia, Hungary and Greece (OECD, 2018).

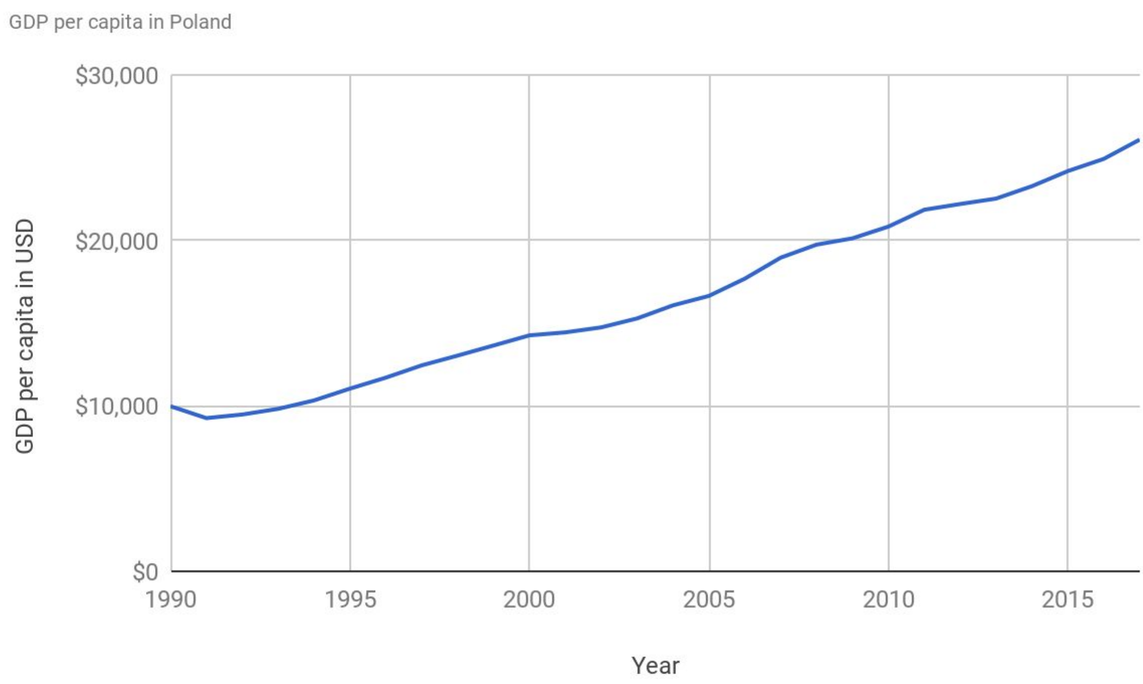

Figure 4.10 GDP per capita in Poland

	2013	2014	2015	2016	2017
Poland	1.39%	3.28%	3.84%	2.97%	4.65%
Ireland	1.64%	8.33%	25.56%	5.14%	7.80%

Table 4.1 GDP per capita percentage growth in Poland and Ireland

4.3.2.3.2 Ireland

To compare, the GDP per capita in Ireland is one of the highest in Europe - 72,485 USD. There is only one country - Luxembourg - that stays ahead. What is also notable is also the growth trend - GDP per capita in Ireland has been growing year over year. The growth rate was even more than 25% in 2015 (OECD, 2018).

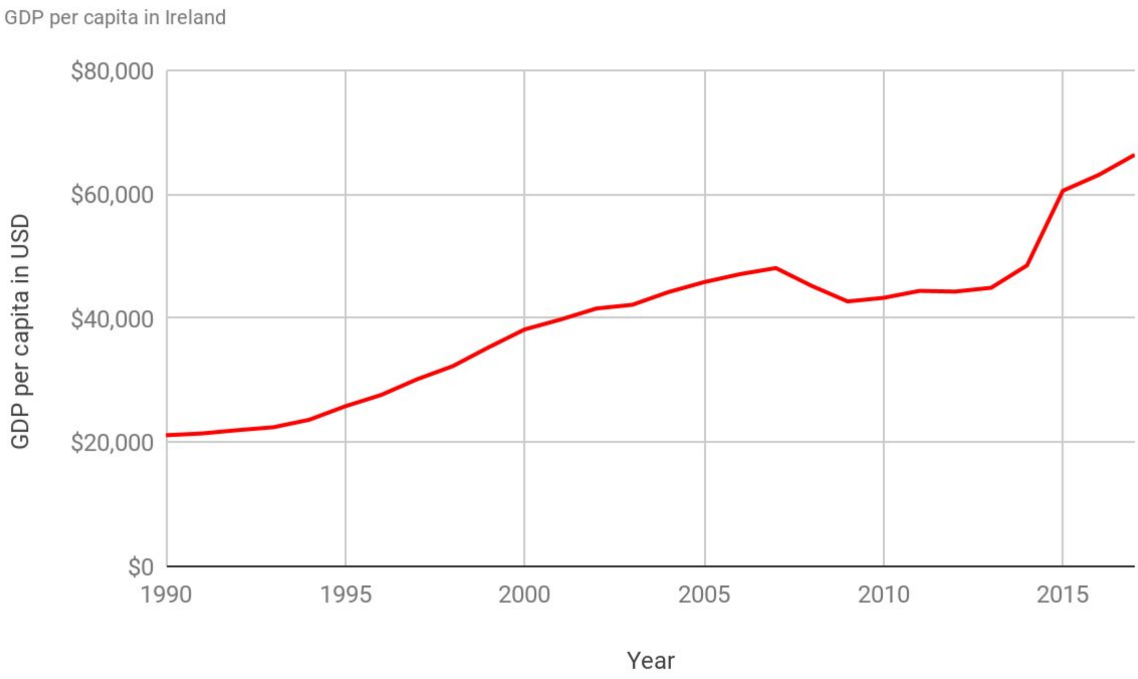

Figure 4.11 GDP per capita in Ireland

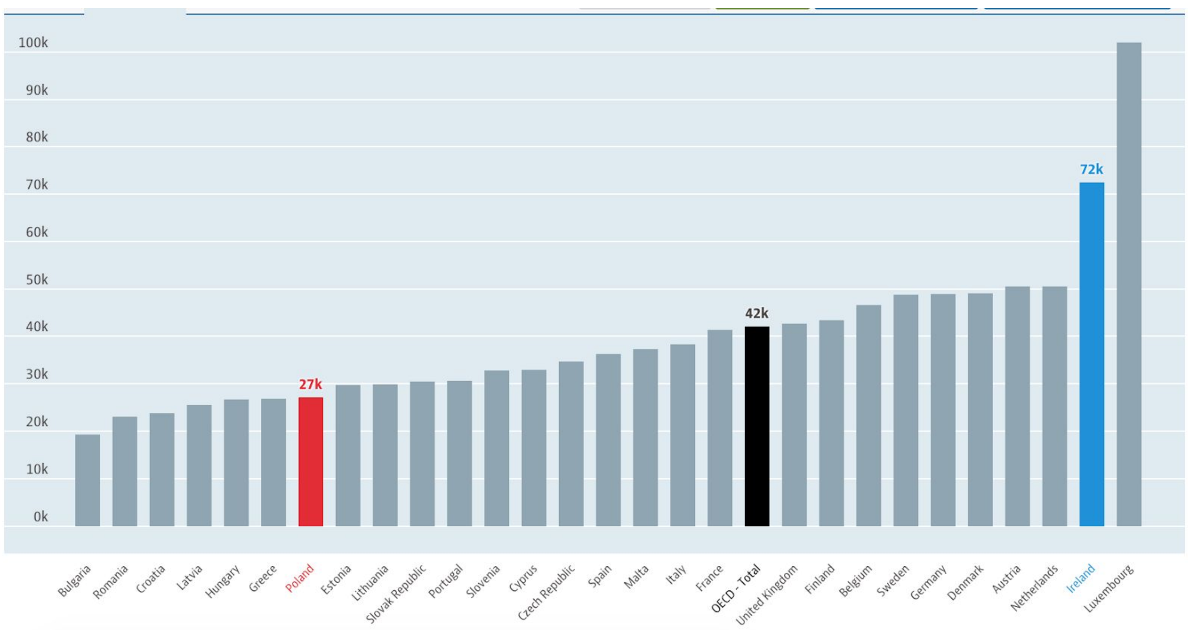

Figure 4.12 GDP per capita in European Union

4.3.3 Labour market

4.3.3.1 Employment rate

As stated by OECD, employment rate is a metric defining the “extent to which available labour resources (people available to work) are being used” (OECD, 2018). Employment rate is the proportion of the workers to the size of the working age population, where the working age population are people at the age between 15 and 64. The report classifies employed people as the ones who stated that they have worked for at least one hour weekly. Employment rate is highly impacted by the state of economy in a country and can be influenced by the governments through the education, social support policies and other employment policies (OECD, 2018). Currently the employment level in Poland and Ireland is close to the average in OECD countries and is 66.5% in Poland and 68.1% in Ireland.

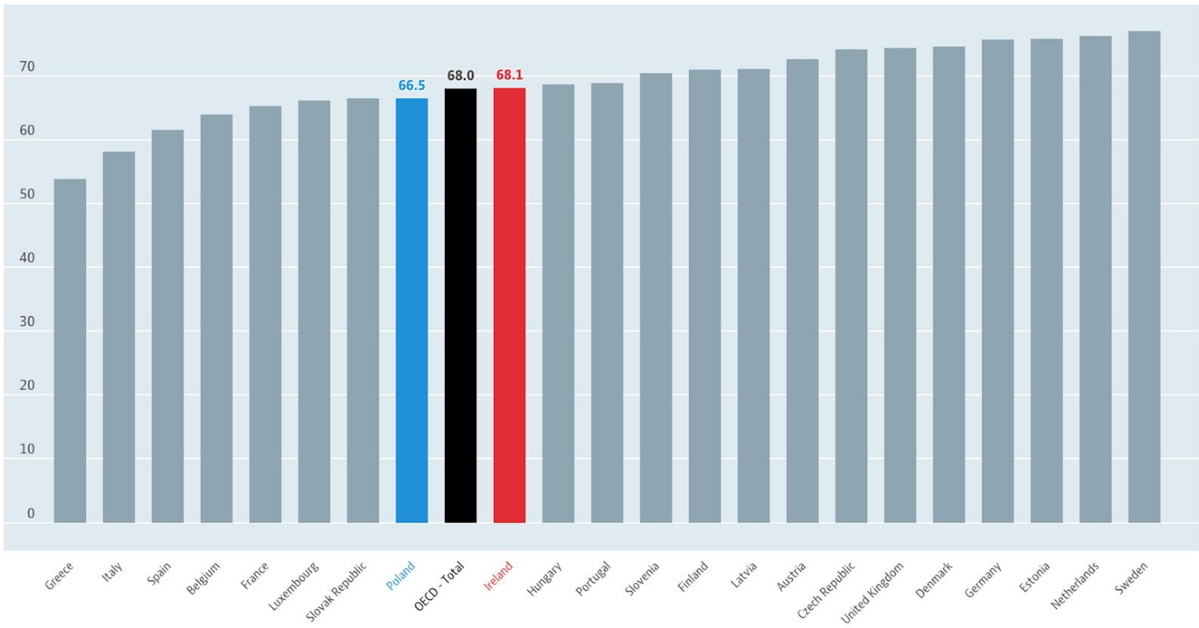

Figure 4.13 Employment rate in European Union

4.3.3.1.1 Poland

The employment rate in Poland has been rising since many years and has been getting closer to the average for European Union year after year. In the second quarter of 2015 the employment rate in Poland was 62.6% and grew to 66% in Q2 2017. The growth is steady and reached 66.5% at the end of 2017 (OECD, 2018).

4.3.3.1.2 Ireland

The employment rate in Ireland is very similar to the European average. It was 0.8 percentage points lower in Q2 2016 (Ireland 64.6% and European Union 65.4%) and has overtaken at the end of 2017 at the level of 68% (OECD, 2018).

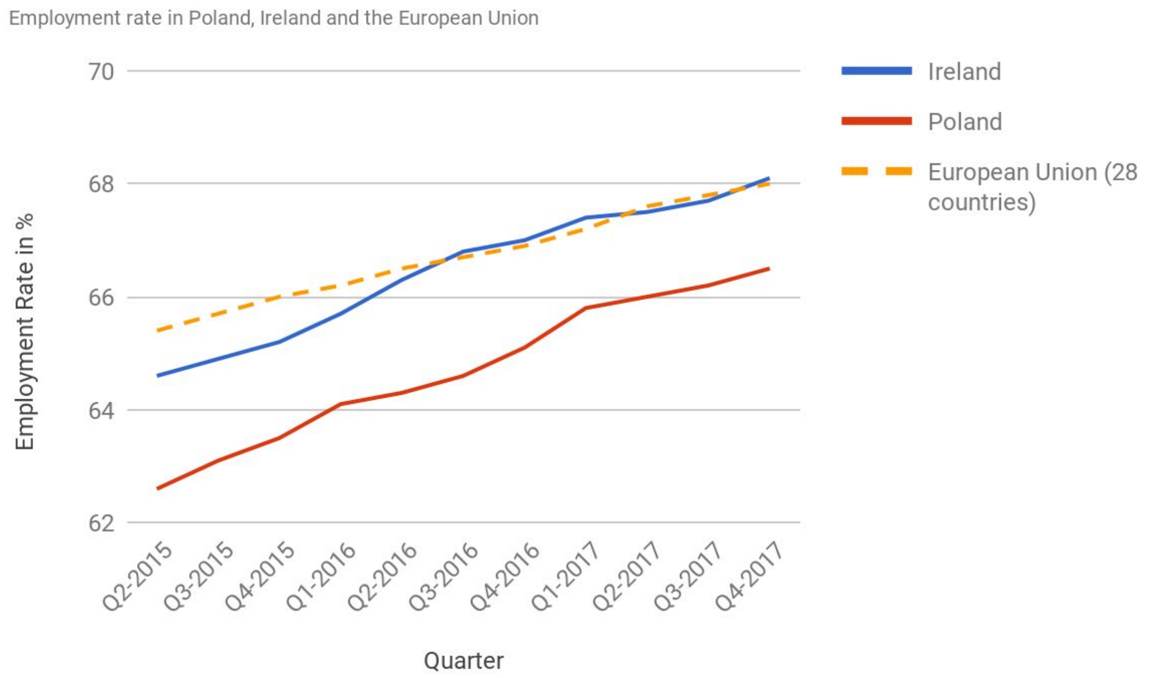

Figure 4.14 Employment rate in Poland, Ireland and European Union

4.3.3.2 Unemployment rate

Unemployment rate is a slightly different metric to employment rate. According to OECD, unemployment rate is the percentage of unemployed population in the labour force of a country. Labour force is composed of unemployed and employed people (paid and self-employed), where unemployed people are those that are available to work and trying to find work, but are unsuccessful for the previous four weeks.

The curve of unemployment rate looks interesting when we compare Poland and Ireland. The unemployment rate in Poland was around 20% in the years 2002 - 2004 and started decreasing after 2004. The unemployment rate in Ireland was lower than 5% in the years 2002 - 2008 and increased dramatically in 2009 and was very close to Poland since then. After a few years of slow growth the unemployment rate started dropping in the year 2013 and is at the level of around 5% in 2018 (OECD, 2018).

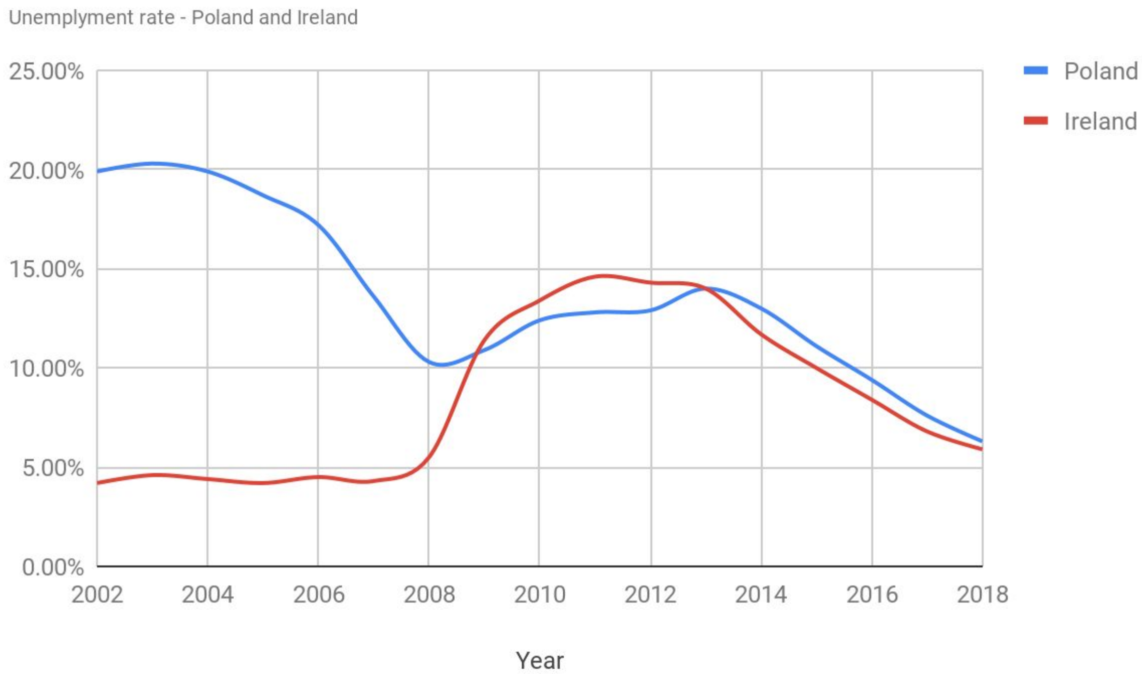

Figure 4.15 Unemployment rate in Poland and Ireland

4.3.3.3 Workweek

The number of hours worked by one employee is another interesting metric to analyze. OECD calculates this metric through dividing the total annual number of hours worked by the average number of employed people in a year. This number takes into account full-time work as well as part-time work, overtime hours both paid and unpaid, employment and self-employment. It excludes the time when employees do not actively work (even though they are paid), for example holiday, illness, healthcare leaves, parental leave, training time etc.

The average number of hours worked in Poland and in Ireland are higher than the average for OECD countries and in the top 5 among European countries.

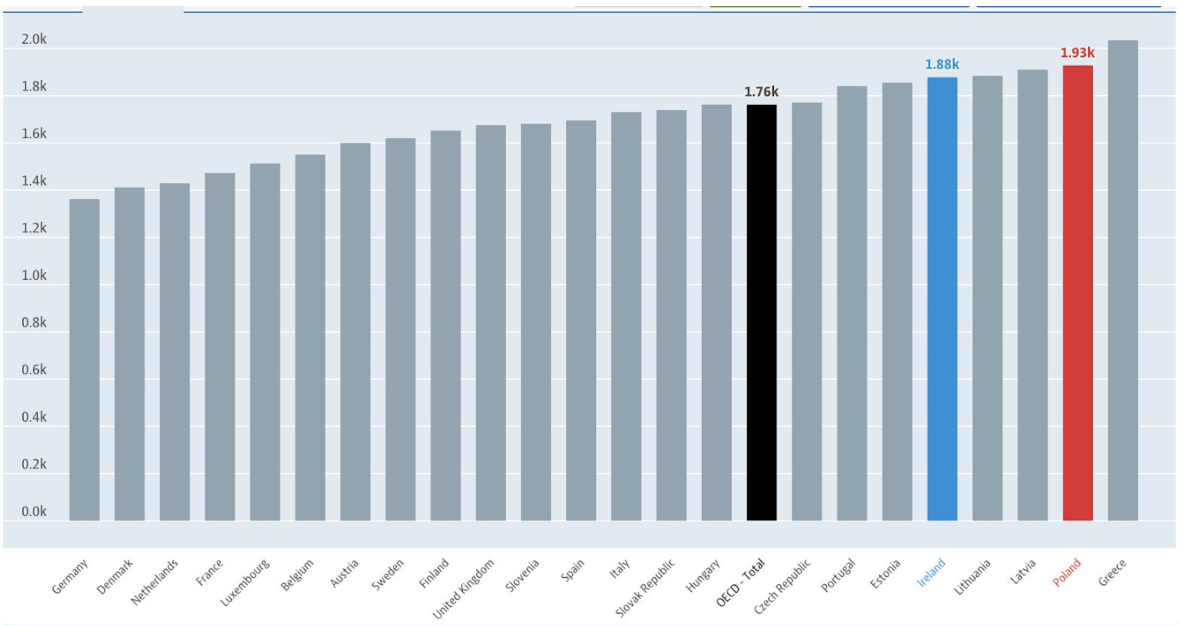

Figure 4.16 Hours worked in European Union 2013-2016

Poland and Ireland represent countries with the number of annual hours worked by employees that is higher than the OECD average and higher than most European countries. However the workweek keeps shrinking year over year and the trend in hours worked is declining in both countries (OECD, 2018).

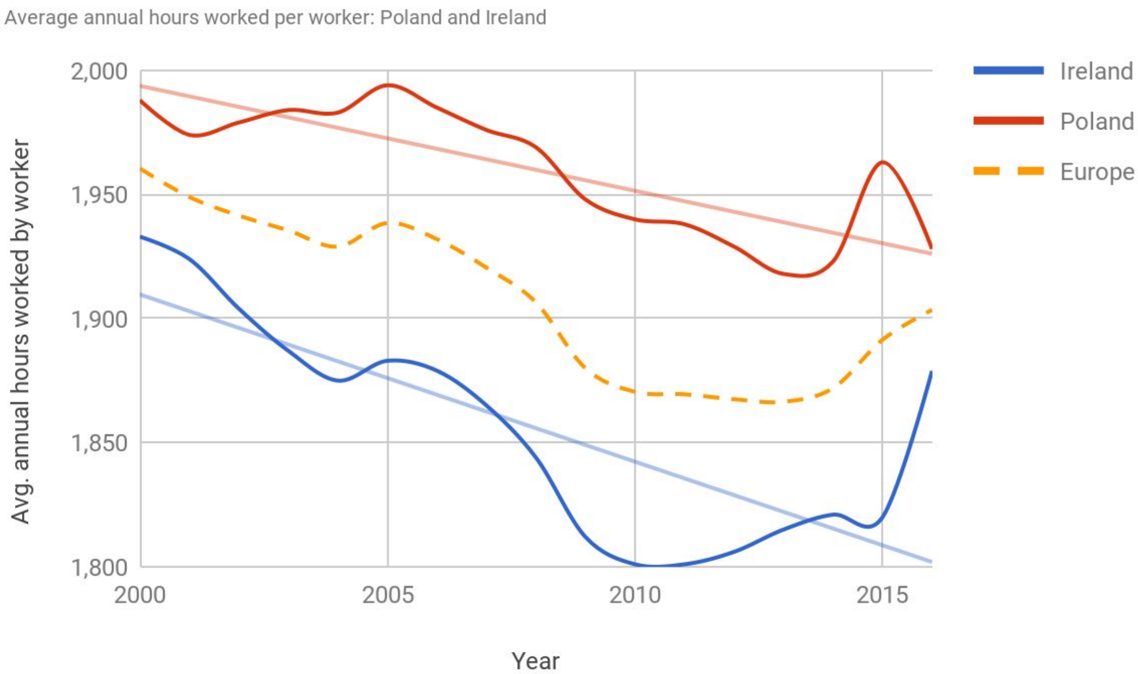

Figure 4.17 Average annual hours worked per worker: Poland and Ireland

4.3.4 Transportation and Logistics

Analysing Transportation and Logistics the author looked at the total amount of freight transport in Poland and Ireland. OECD defines total inland freight transport as “any movement of goods using a vehicle on a given network and it includes rail, road, inland waterways and pipeline when they exist” (OECD, 2018). Tonne-kilometre is a metric that helps to define the size of the Transportation industry. It is a “measurement of goods transport which represents the transport of one tonne of goods over a distance of one kilometre” (OECD, 2018).

The freight transport in Poland grows much more dynamically than the freight transport in Ireland. In Poland the freight transport grew from around 15 billions tonnes-kilometers in 2000 to around 40 billions 16 years later. The freight transport in Ireland has been stable at the level of one billion tonnes-kilometers (OECD, 2018).

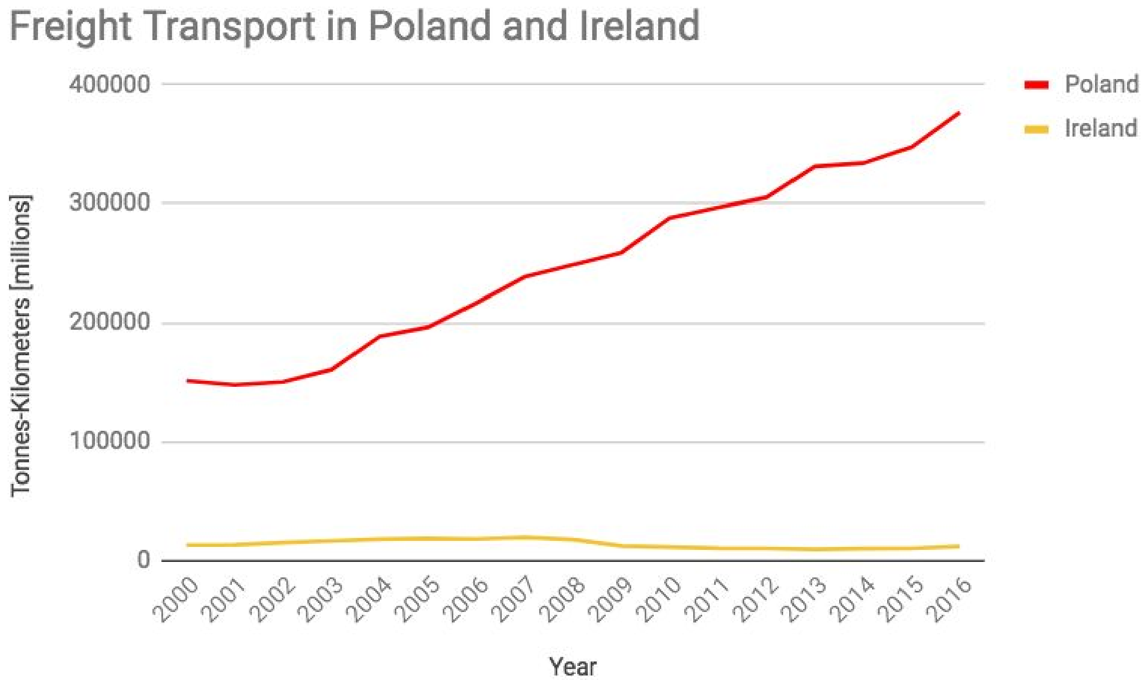

Figure 4.18 Freight Transport in Poland and Ireland

4.3.4.1 Average monthly salaries in Transportation and Logistics

Transportation and Logistics is a sector that follows the major economic trends in both Ireland and Poland. The average monthly salaries in this vertical grow steadily in both countries. In Poland the average salary grew by around 10% from 900 EUR monthly in 2009 to around 1000 EUR per month in 2017. In Ireland - where the GDP per capita is three times higher than in Poland - the average salary in Transportation and Logistics is also three times higher and it grew from 2600 EUR in 2009 to 3200 EUR in 2017 (Stat.gov.pl, 2018).

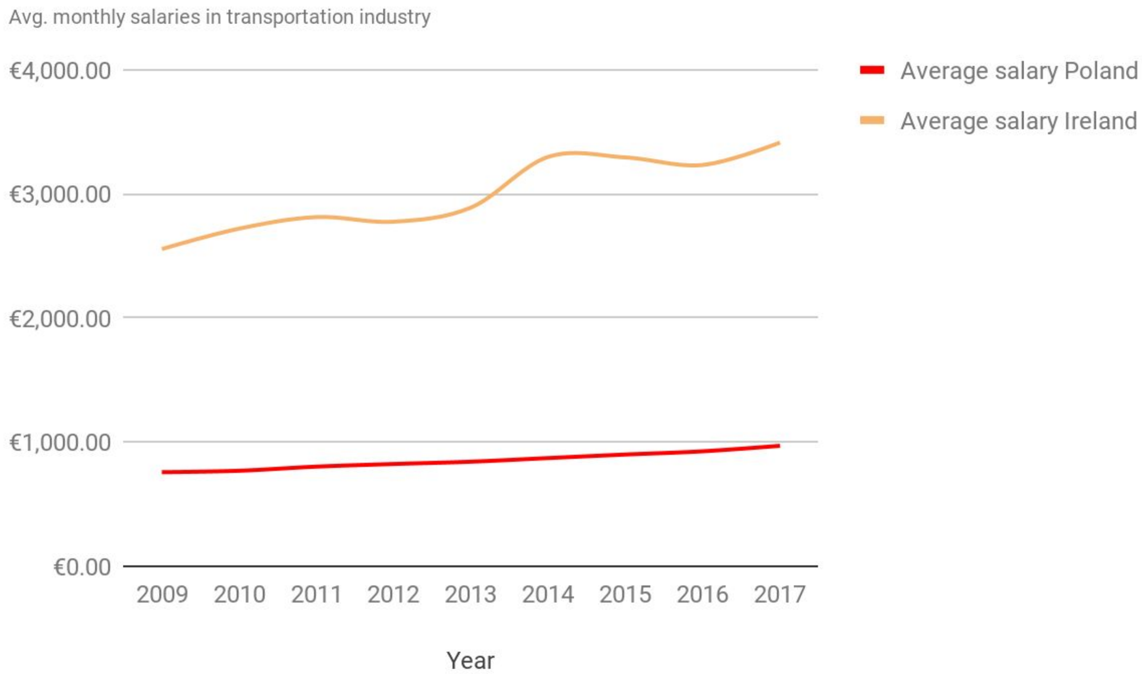

Figure 4.19 Average monthly salaries in transportation industry in Poland and Ireland

4.3.4.2 Employment in Transportation and Logistics

The number of people employed in Transportation and Logistics grows year over year in both Poland and Ireland, however there are ten times more people working in Transportation in Poland than in Ireland. In Poland the number of people working in Transportation grew from 900,000 in 2012 to around 975,000 in 2016. In Ireland the percentage of growth was similar but the total numbers are ten times lower. In 2012 there were 90,000 people employed in Transportation and in 2016 Transportation had 96,000 employees (OECD, 2018).

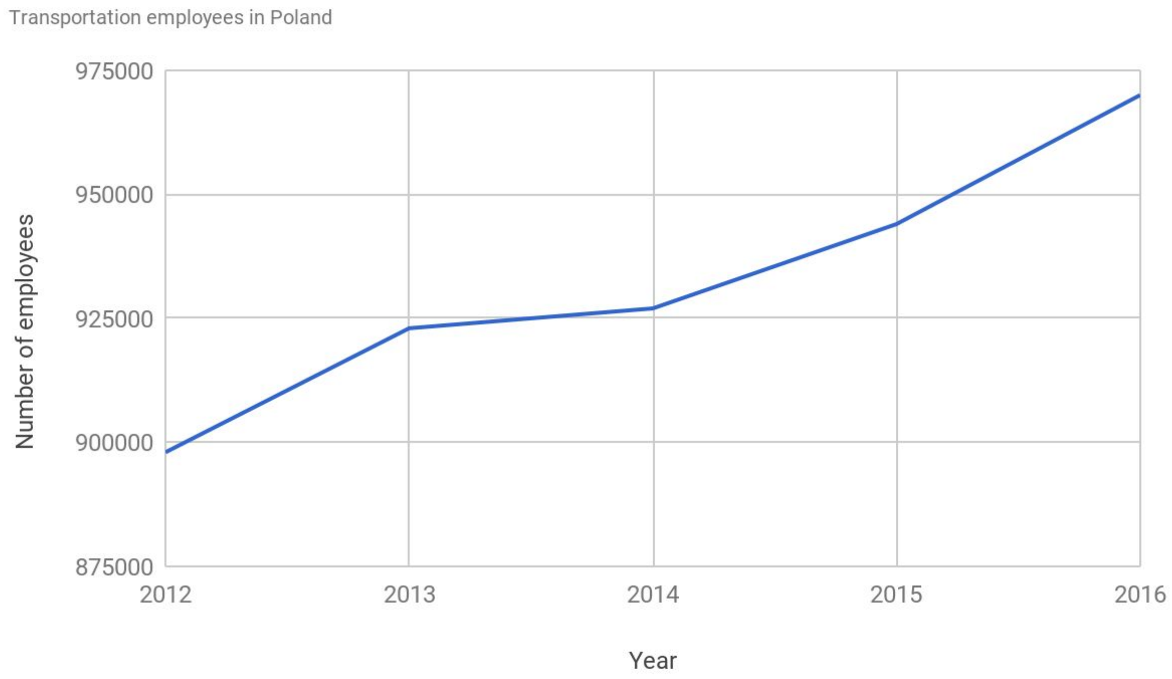

Figure 4.20 Transportation employees in Poland

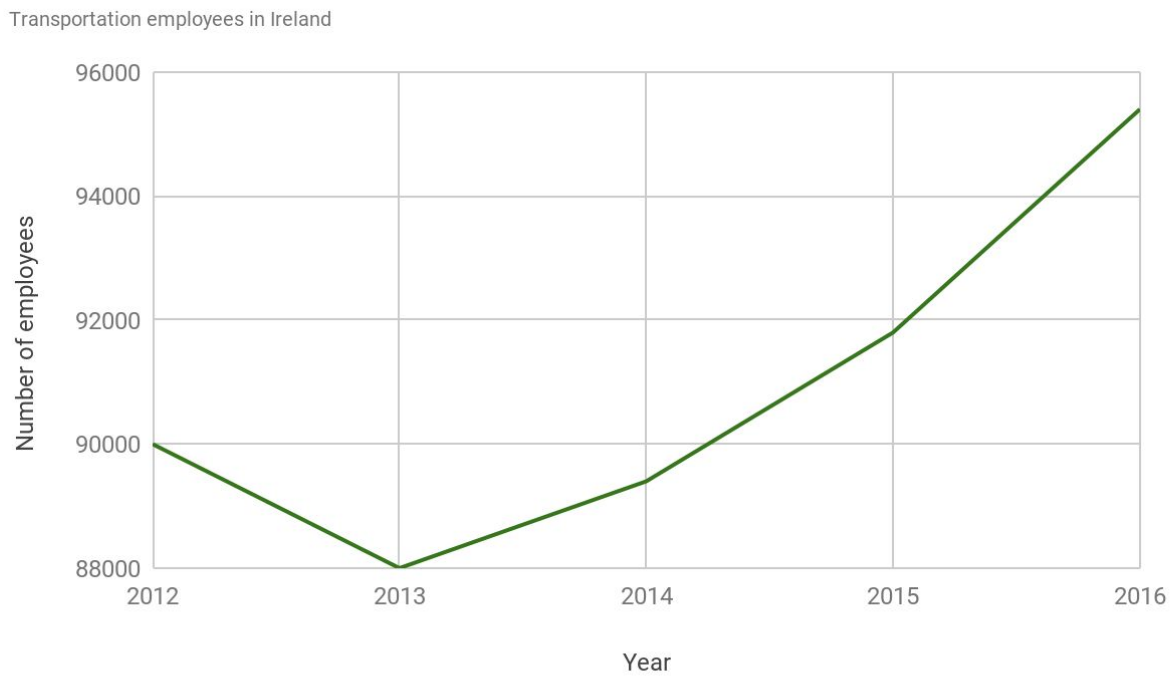

Figure 4.21 Transportation employees in Ireland

4.3.4.3 Vacancies in Transportation

Analyzing closer the job market in Transportation it is remarkable that the share of vacancies in the Transportation industry in Poland to the total vacancies grows year over year and was over 10% in 2017 versus 7% in 2013 (Stat.gov.pl, 2018).

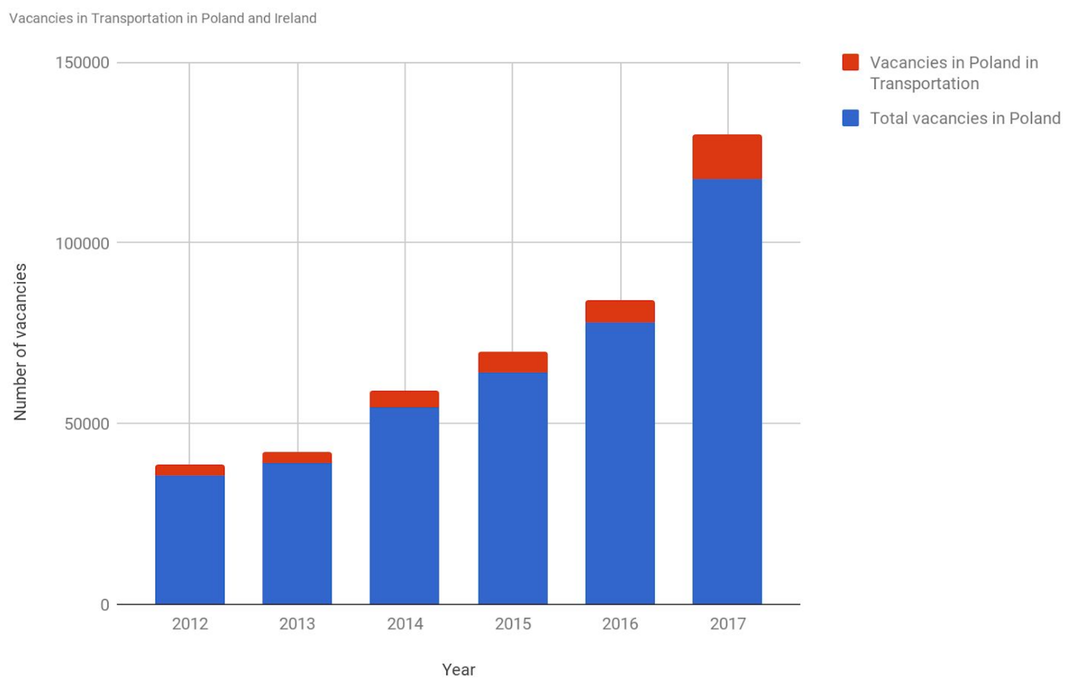

Figure 4.22 Vacancies in Transportation in Poland and Ireland

5. Conclusions and Future Work

5.1 Introduction

The main objective of this research is to analyse the impact of artificial intelligence technologies on modern society from the perspective of employment, with a focus on the Transportation and Logistics vertical. The author closely considered two European countries, Poland and Ireland. The following chapter presents the conclusions of the research, describes its limitations, and provides suggestions for further studies in this area.

5.2 Conclusions

The research aimed to prove the hypothesis that artificial intelligence has a significant impact on employment in the transportation and logistics industry in Ireland and Poland.

However, this was found to not be the case, as it does not cause any shrinkage in the labour demand, nor does it facilitate unemployment.

5.2.1 Demography

Demographic projections executed by the United Nations show that most European countries currently have to manage ageing societies. Poland is one of the countries on the European continent where the population will decline by more than 15% within the next number of decades. The fertility rate in Poland tends to be low – lower than the level necessary to retain a stable population size, which is 2.1 children per one woman. Poland also has one of the lowest natural population increase rates in Europe; this was roughly zero from 2000 to 2005, and dropped to a negative value as of 2005. In comparison, the average lifespan is increasing. The average life span was 77 years in Europe in the years from 2005 to 2010, and this trend is still growing. Europe is also the continent with the largest percentage of older populations; in 2025, every fifth inhabitant is projected to be older than 64. The share of elderly people in the entire European population keeps growing, and is projected to be 30% in 2100. The situation in Poland is even more dramatic. The ratio of elderly people to working age people will increase to 30% by 2050, 50 years prior to the whole of the European continent. Alongside the growth of older population groups, the working age population keeps decreasing, and is projected to drop from 71.3% in 2010 to less than 60% in 2050, and 52.8% in 2100. By 2100 only half of the Polish population will be actively working and supporting the countries budget (Esa.un.org, 2018).

Ireland is experiencing a similar situation; however, the size of the Irish population will remain more stable. Currently, the rate of natural increase is positive. Despite the fact that this trend will decline, it is not projected to reach a negative value prior to 2100. Nevertheless, the size of the population aged 65 and older will continue to grow up to 2060. As such, both Poland and Ireland are facing the phenomenon of an ageing population.

The support ratio (the amount of people employed per one retiree) has been heavily impacted by an ageing population. It is predicted that this situation will undermine the financial status of many countries worldwide. Public systems managing healthcare, pensions, and social support will have to adapt to a new societal structure alongside a growing older population.

5.2.2 Economy

Regarding the economic situation in Europe, most countries provide improvements in living standards, as is also the case for Poland and Ireland. The average wage in both countries has grown dynamically over the past 15 years. The growth rate of the salaries, both in Poland and Ireland, has been roughly 30%. Many economists define GDP per capita as the best indicator for the living standard within a society, and this metric has been steadily growing in Poland and Ireland.

5.2.3 Labour

Regarding the employment market, Poland and Ireland are the two countries closest to the European average, and the employment rate in both has been growing since 2015. Compared to the unemployment rate, this metric has been more volatile since the start of the 21st century, but has been dropping steadily since 2013 in both Poland and Ireland.

Concerning the amount of work that the Polish and Irish populations carry out, the number of working hours are higher in these two countries than in others in Europe, but overall, this tendency is dropping.

5.2.4 Transport

Freight transport is growing within the whole of Europe, and particularly in Poland. This vertical industry has always been larger in Poland than in Ireland, but the current scale has increased significantly in recent years, reaching 40 billion tonnes-kilometres in 2016, which is 260% more than in 2000. The dramatic growth in this vertical industry is accelerated by growth in the Polish economy in general, in addition to significant growth in the retail sector, as well as e-commerce. This incredibly fast expansion in vertical transportation has created new jobs, while also increasing the demand for transportation and logistics workers, both highly-skilled and low- and medium-skilled.

Currently, almost one million people in Poland are employed in Transportation only. Unfortunately, there is no data on the logistics sector as a whole, but one can assume that growth in this sector is at a similarly high level. The number of vacancies is growing dynamically, and the gap between the labour force supply and demand keeps growing. This has given rise to a strong increase in salaries in transportation, which rose by 10% over the previous eight years. Looking at demographic trends, if the economy continues to grow steadily, and consumption on the part of the Polish population grows, the transportation sector will not shrink, and the gap in the labour force will continue to grow larger. In 2017, 10% of vacancies in Poland were in the vertical transportation sector. Transportation and logistics therefore require new and intelligent technologies to enable employees to complete their work faster and more effectively.

5.2.5 Summary

According to economist Hal Varian, demographics is the only science that can accurately predict the future. We can barely forecast the impact that technology might have over the next 10 years, and no science can be entirely confident about the impact technology might have on the global population long-term. A range of different research institutions are attempting to predict aspects such as job losses due to the development of artificial intelligence, but there is no alignment between these predictions. For example, Oxford University estimates job losses of more than 50%, PricewaterhouseCoopers estimates it to be close to 40%, while the OECD, ITIF, and Forrester and McKinsey predict this number to be less than 10%. The has reported on jobs being taken away from humans by machines since 1980; however, since then, only one occupation has been removed from the list of 270 occupations in the United States, this being ‘elevator operator’. Automation and modern technologies do not eliminate jobs; rather, they eliminate tasks. To eliminate the entire job, one would have to eliminate all the tasks that are linked to this particular position.

With the ageing population in Ireland and Poland, fewer people are able to take on a professional occupation. At the same time, the wealth of the society in Poland and Ireland keeps growing; people have more resources to spend on goods and services. Additionally, with a decrease in working week hours, the working age population has more opportunities for consumption. Higher consumption powers different business sectors and has a significant impact on growth in transportation and logistics sectors. For example, in Poland in 2017, manufacturing grew by 5.5%, retail grew by 7%, e-commerce by between 12% to 15%, while prices grew by only 1.5%. The purchasing power of Polish society is strong, and there are many different goods and services on the market. To accompany this growth, the amount of warehousing space grew in 2017 by 17%, compared to 2016. In June 2017, there were 800 thousand square metres of warehousing, more than in June 2016, with another 1.6 million square metres under construction. Additionally, there is a significant need for technology that can accompany the rapid growth of vertical transportation and logistics, as well as the lacking labour force (Stat.gov.pl, 2018).

Consumption in Poland and Ireland is growing faster than the labour force and as such, technological improvements are crucial for compensating the resulting gap. The invention of self-driving vehicles and other technologies that can support warehousing workers will help the industry to grow and support the population's needs. Automation allows for automating certain tasks, but does not eliminate entire jobs in transportation and logistics; for example, there will still be the need for individuals to operate machines in a warehouse, even if the machines support humans in some tasks. While there is a larger need for highly-skilled workers, the need for low-skilled workers does not decrease because of economic growth and low supply. A decreasing supply of labour in transportation and logistics is a primary issue in Poland and Ireland, and the main reason why these societies need automation and other intelligent solutions.

5.3 Limitation of the research

The research is limited by the fact that there is no science that will be able to accurately predict the future of technology and its long-term impact on any society. The author based his conclusions on the demographic and economic data related to Poland and Ireland, as gathered by the United Nations and the OECD, and as such, could not influence the survey topics or the questions asked. There is a limited amount of data available for secondary research, and what is available refers only to transportation and logistics; therefor, some of the conclusions have to be made based on a population as a whole. The author was able to find interesting research about transportation, but logistics is a sector that has to date not been evaluated in detail. There is also lacking information on the skills of workers who are required in the transportation and logistics sector, and about trends related to how these skills have changed in recent years.

5.4 Future research opportunities

The author hopes for this research to continue and to be limited to the population employed in the transportation and logistics sector. The secondary data research provides a broad view of the demographic, economic, and social situation of the populations in Poland and Ireland; however, the author suggests conducting primary research involving a population sample that is smaller, but also limited to transportation and logistics employees. The researcher can combine quantitative research with a qualitative approach in order to more closely examine the influence of modern technologies on the day-to-day tasks of employees, the evolution and transformation of job specifics, and changes in employment structure.

5.5 Summary

Intelligent technologies have developed at a rapid pace over the past number of years. AI methods such as evolutionary algorithms, artificial neural networks, simulated annealing, and ant colony optimisation, support the growth of automation and the development of intelligent agents. These modern technologies have already been experimented with in the transportation and logistics sectors; for example, bionic enhancement has been tested in warehouses to support workers in carrying heavy objects. Self-driving vehicles is a technology that has been significantly developed for many years, and we can expect it to be implemented in the warehousing environment within the next few years.

Poland and Ireland represent ageing populations, where artificial intelligence and the development of automation technologies can allow for rapid economic growth. It supports bridging the gap between a lacking labour force supply and an increase in the demand for goods and services. The Polish economy is accelerating, and the labour demand is currently higher than the labour supply. This situation is similar in Ireland, which has one of the highest GDP rates per capita in Europe. In this context, implementation of modern, intelligent technologies and the automation of repetitive work tasks will increase the efficiency of the transportation and logistics sectors, and support the gap between the workforce supply and demand in these sectors.

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