The potential impact of Autonomous vehicles on the labor market in The Netherlands

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The potential impact of Autonomous vehicles on the labor market in The Netherlands

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Delft, April 2020

Summary

This thesis research examined how the introduction of Autonomous Vehicles (AVs) affects the labor market in The Netherlands related to skills and job types. The development and research on AVs have done in the Netherlands make it be the readiest country in the world to use AVs on the road. The AVs have promised to deliver safer travel to passengers from one destination to another destination. Other promises include a reduction in traffic congestion, an increase in fuel efficiency and more. However, the AV introduction will be having a few disadvantages. Some of them are lack in privacy and data protection, unemployment in certain labor workforce. As evident in the history of technological advancement, there will be many challenges, opportunities, disruptions, and changes in the current labor market after the introduction of AV technology too. This might lead to a rise in some of the jobs and skills, whereas on the other hand there might be a decline or replacement of jobs too.

Previously, AVs' research has been mainly technical, trust, public acceptance. There has been minimal research on the socio-economic impact on society. Few pieces of research have been done in countries like the European Union, Canada, United States, Australia, and New Zealand on the effect of employment in individual countries and globally due to AVs. There has been a fear that due to the change in geography and technological change, there is possibility that it threatens the laborers' mismatch with their skill and job types. Over multiple decades due to the mismatch between laborers skills and job types, it has increased the demand and supply for new skills. To the researcher's best knowledge there has been no research done in the Netherlands on how the highest automation level of AVs will affect employment. As already mentioned before, Netherlands is the readiest country in the world to use AVs on road, hence it is necessary to understand its effect on the labor market. Therefore, this MSc research thesis aims to answer the following research question.

"How might the introduction of autonomous vehicles influence the labor market related to potential changes in skills and job types in the Netherlands?"

To answer the main research question, a qualitative approach was adopted. This involved two data collection phases. The first phase involved reviewing literature which helped in creating a conceptual model, showing the relationship between the AV technology, labor market and skill mismatch. This can be seen in *Figure X.* As the new technology or innovation emerges to society, there will be a demand for skills and laborers. The demand increases as innovation are widely used in society and subsequently, there should be a supply of skills to meet the demand. This causes an imbalance between the skill demand and skill supply. This imbalance is termed as a skill mismatch. The cause of skill mismatch is due to factors such as *skill shortage, skill gap, skill obsolescence, over education or under education and overqualification or under qualification.* These skill mismatch factors will be resulting in greater unemployment for a short and long duration of time depending on the timeline of introduction of various levels of AVs.

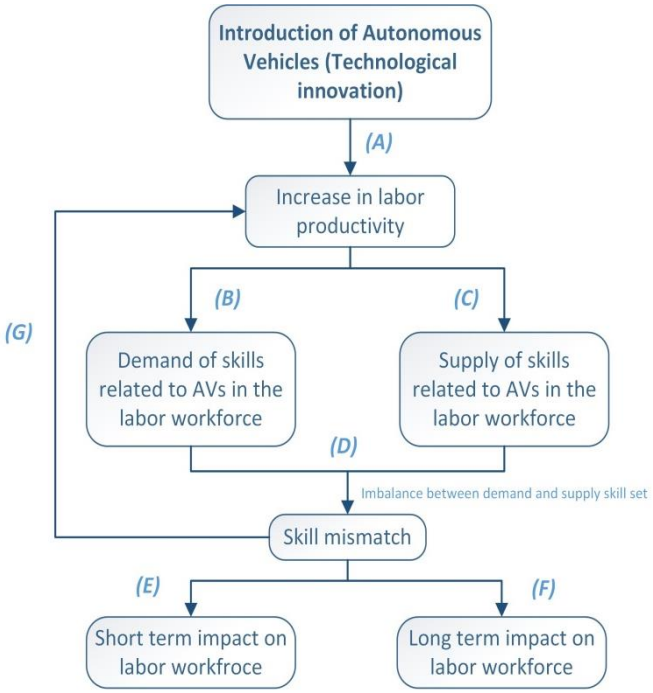

***Figure X*: Conceptual model of the relation between AVs, labor market and skill mismatch**

The second phase of the research involved, interviewing academicians from various universities in The Netherlands and experts from the labor organization of The Netherlands. The interviewers were maximum from academia. There was a total of 13 interviewees, out of which 12 were academia and 1 from a labor organization. The research lens from the literature was used to formulate interview questions. Finally, the qualitative data of the report has been analyzed by the coding procedure.

Based on the interviews, 83 factors were identified related to problems and causes of skill mismatch on the labor market due to the introduction of AVs. A list of top code (factors) based on the highest frequency mentioned by the 13 interviewees was created. The codes can be categorised into 6 categories. The result showed that the skill mismatch problem is a minimal issue in the labor market when the highest level automation of AVs is being introduced in The Neherlands. The majority of the interviewees predicted that the skill mismatch problem is not the main factor that affects the labor market, but it is one of the factors along with wage effect, GDP and more. And skill mismatch factor will be having lesser effect on labor market. But, interviewees expressed that at the introduction of the highest level of automation of AVs, there will be a rise in unemployment in certain labor workforces, like the trucking and passenger transport industry as their main job i.e. driving will be taken away from them. There is a prediction there will be resistance towards this scenario by labor union organization. Apart from the trucking and passenger industry, laborers that are under-educated or under qualified, employers who are having skill shortages or skill gaps, experience a rise in unemployment. The majority of the interviewee predicted skill mismatch to be a short term problem. Also, they had an opinion that the involvement of government and their collaboration with the labor

workforce will be helpful in mitigating the skill mismatch problem. By creating new policies to protect the low skilled labors, organizing retraining progragrams for laborers who need extra skills and improving educational system.

To conclude, in general the interviewees had opinion that the skill mismatch is not a major concern in The Netherlands. The interviewees were skeptical about the emergence of the highest automation level of AVs. Some of them had an opinion that the emergence of the highest automation level of AVs would never happen. The opinion of the interviewees varied for a few of the interview questions. Some of them disagreed that it will be affecting and not being the main factor, however, some of them agreed that it will be definitely the main factor that influences the labor market. Even though if there would be a skill mismatch problem, according to some of the interviewees the problem could only persist for a shorter period of time. However, some of the samples had an opinion that it may persist longer than expected and it may depend on which intervals the AVs are introduced to society. The involvement and collaboration between various stakeholders like government, labor union organization, employers and more can minimize the skill mismatch issue in The Netherlands. Steps like retraining, repositioning, improvement of the educational system and more.

The results of this research had its contribution to a scientific and practical approach. The approach of semi-structured interviews with academia made it a unique case within the field of research on the effect of the highest automation level of AVs on the labor market. By this interview process, gave opportunity towards understanding the perspective from the academic point of view from different departments. Nevertheless, there was some limitation to this research. This research mainly focused on how the AVs that will be affecting the labor market related to skills and job types, there are many other factors like wage effect, GDP and more which affect the labor market of the country. If the sample size was working laborers from the labor workforce, we would have got more insights on how the AVs introduction will affect their industries related to skills and job types. To understand how important the skill mismatch is problem from employer's point of view.

There are a few recommendations that can be helpful in leading the direction for future research. The research was mainly focused in The Netherlands, the impact on the labor market has to be seen as the global impact and it differs from country to country. So generalizing the result would be a difficult part of this study. The main agenda of the research was to answer why and how question. There is provision to do research to answer how much and how many types of jobs and tasks will be affected by the introduction of AVs. Interviewing experts from the labor workforce will lead to more insights on impact of AVs on job types and skills. Also, this research can help policy – law by exploring strategies and policy options to enhance positive job impacts and minimize negative impact in the labor market.

Table of Contents

List of figures

List of tables

Chapter 1: Introduction

1.1 Introduction

The automobile industry has been continuously working on bringing automation in motor vehicles for the betterment of human life. Over the years, cars have been programmed for adaptive cruise control, parking assists, reverse assist and other functions that require less human interaction. Advancement in technology has helped companies manufacture cars that can drive and navigate on their own, called autonomous vehicles (AVs) or self-driving cars (Fagnant & Kockelman, 2015). AVs have a significant impact on the urban and transportation system. They can lead to changes in traffic congestion, vehicle emissions, and infrastructural requirements. Apart from this, AVs also have socio-economic implications in sectors such as technology, telecommunications, insurance, transportation and logistics (Bagloee et al., 2016; Chan, 2017; Fagnant & Kockelman, 2015; Milakis et al., 2017).

There are many advantages and disadvantages, as stated by various authors, (Bansal & Kockelman, 2018; Fagnant & Kockelman, 2015; Pettigrew et al., 2018) of the AVs in the society. The potential benefits are reduction in traffic accidents, hence enhancing the safety of the drivers, fellow passengers and other pedestrians on the road, reduction in emission and easy transportation for disabled and elderly people, reduced traffic congestion, an increase in fuel efficiency and more. Potential disadvantages include privacy, data protection, unemployment in individual labor workforces, insurance and liabilities, public acceptance and ethical considerations (Pettigrew et al., 2018).

Research on the socio-economic effect of AVs is gradually getting attention, given its importance for the betterment of life and business conditions of citizens (Després et al., 2018). The current pace of development on AVs might soon lead to the domination of the automotive industry by AVs. Once the automotive market is dominated by AVs, Clements & Kockelman claim that AVs will have a huge impact on the industrial and market economy around the world. Studies by (Clements & Kockelman, 2017; Hussain et al., 2018) suggest that increase in the adoption of AVs might further increase the impact of AVs on the labor market in industrial sectors and service sectors. Industrial sectors include automotive, electronics and software, telecommunication, data service, and digital media sectors. In service sectors it includes freight, taxi transport and insurance sectors (Clements & Kockelman, 2017; Després et al., 2018). As seen in the history of technological advancement challenges, opportunities, disruptions and changes will be evident in the current labor market after the introduction of AV technology too. This might lead to a rise in some of the jobs and skills. Whereas on the other hand there might be a decline or replacement jobs (Cutean, 2017). AVs have the potential to create highly skilled jobs in some of the sectors like automotive, manufacturing, Information and Communications Technologies (ICT), electronics and software industry. As with any innovation, this also has positive and negative effects on society. In contrast to creating jobs AVs are also predicted to create unemployment in different sectors (Després et al., 2018; Frisoni et al., 2016 2016;

Pettigrew et al., 2018). Research by (Clements & Kockelman, 2017; Després et al., 2018) suggests that the taxi sector and freight industry will be most affected by the introduction of AVs. A survey conducted by the DG internal policy concludes that around 2.4 million people, currently working in the freight sector in Europe, might be affected by the introduction of AVs in the freight transportation industry (Frisoni et al., 2016). In general, from the advancement in technology, it creates uncertainty in the supply and demand of the firm. Uncertain firms are more cautious about the investment decision on their employees about training them for new skills or jobs (Bloom et al., 2006).

From the historical trends due to technological change, there will be an emergence of new types of jobs and skills in the AV technology field too. But there is no guarantee that each individual will be benefited from the outcome. For example, older employees in the firm might have a tough time getting accustomed to the newer technology used by the firm. Hence it is less beneficial for older employees. To sum up, the effect of advancement in technology is unclear and uncertain on the supply and demand side of the labor market. This tends to have an impact on the overall performance of the labor market such as change and improvement of skills and replacement of workers. Consulting companies and many researchers are constantly working to understand how AV technology will lead to the development of new skills and jobs in global scale and individual countries. A few of them are highlighted in the following section.

Despite being reliable and affordable, the timeline for the implementation of AVs is uncertain and varying. The literature claims that the speed with which the AVs are introduced into the market is certainly not in coherence with its adaptability by society (Clements & Kockelman, 2017; Pettigrew et al., 2018). In the coming future, it is predicted that there will be a requirement and demand of highly skilled professionals which will give rise to inequality between low skilled and highly skilled laborers (Després et al., 2018). The impact of AVs on jobs and skills mainly depends on the speed of its introduction and change in mobility. Gradually the introductions of technology, the better the negative impacts get absorbed by society.

1.2 Research problem and objective

The idea of AV is not far from reality. Waymo, an AV by Alphabet has completed its milestone journey on road without a driver (Marr, 2018). The market deployment of AV is getting closer and as a technology, it has its own significance. Hence, questions are being raised on its economic and social implications (Després et al., 2018).

Currently, there is very limited research done by the European Union, Canada, the United States, Australia, and New Zealand on the effect of employment in individual countries and globally due to AVs. However, there is no research in The Netherlands on how the AVs will have their effect on employment in various industrial and service sectors based on skills and job types. The JRC report by Després et al.,(2018) titled “An analysis of possible socio-economic effects of a Cooperative, Connected and Automated Mobility (CCAM) in Europe - Effects of automated driving on the economy, employment and skills'' focuses on Europe as a whole.

Certain industries like the manufacturing industry vary significantly across European countries. It is predicted that Romania and the United Kingdom might be having the largest expansion in automotive employment. Whereas, Germany being the dominant player in the automotive sector it is predicted that there will be a small increase in employment. In other countries such as Poland, Italy and France the employment in the automotive sector will decline. This is all dependent on the taxation, average level of education and other country-specific characteristics (Després et al., 2018). There has been a fear that changes in geography and technological change threatens the employee's mismatch with their skill and job (Ozgen et al., 2015). Over multiple decades this mismatch has increased the demand for new skills and the supply is maintained by increasing the education level of workers. This demand for skill can be related to technological change (Acemoglu & Autor, 2011). Hence it differs from country to country. There might not be the same level of requirement of skills and jobs in the sector in all the European countries. Acemoglu & Autor (2011) concluded that the countries which went through the same technological change have not experienced the same change in the labor market. According report by KPMG (2019) Netherlands has been one of the most ready countries in the world for the introduction of the AVs. Netherlands was listed in the top for Autonomous vehicle readiness index (AVRI) based on four pillars. These pillars are policy and legislation, technology and innovation, infrastructure, and consumer acceptance. Netherlands ranked topped in all the pillars. Depending on the AVRI the socio economic impact of AVs differs from country to country. Hence it is necessary to understand the socio economic impact of AVs on the society particularly in The Netherlands. Since as the country the Netherlands has ranked highest in the consumer acceptance, it is necessary to do research on how the introduction of AVs will have its impact on labor market. The Netherlands as an individual country of the European Union might have a different requirement and effect on the type of skills and job types. Hence the primary objective of this research is to find out the potential impact of AVs on labor market in the Netherlands in terms of the requirement of jobs and skills in industrial and service sectors.

To address this gap there is a need for ***"contribution of scientific knowledge in understanding how the autonomous vehicles have its effect on employment in terms of the type of jobs and skill in The Netherlands."***

In order to achieve the above objective, it is required to achieve the following secondary objective

- Analyzing how the introduction of automation and artificial intelligence, one of the main technology which is involved in the development of AVs has affected the type of jobs and skills when they were introduced in the first world countries.
- Identifying economic sectors which are likely to get affected by AVs
- Identifying which type of jobs might be affected by the introduction of AVs
- Analyzing the effect of skill mismatch on the employment status due to technological change.

1.3 Research Relevance

It is predicted that the widespread use of AVs will have a profound impact on various industries and markets around the globe. Depending on the adoption rate of the technology the economic effects will be varying (Clements & Kockelman, 2017). AV adaptation has to tackle its societal challenges like unemployment and it is necessary to understand the problem and its consequences. There should be policies undertaken by the government to compensate for the suffering caused by types of skill mismatches. These challenges are conceded in the report "Transformative technologies and their jobs in the future" by the Organization for Economic Co-operation and Development (OECD). This particular report is taken as a reference by the G7 Innovation Ministers Meeting for the year 2018. It is discussed in the report that it is the responsibility of the government to form policies that can facilitate the change in the labor market (OECD, 2018).

The Netherlands is one of many countries that will be experiencing a fourth revolution in redefining and reallocating its labor market (Gray, 2017). As employment is one of the major factors which influence the economic growth of a country it is necessary to understand how one emerging technology has its effect. There are very few studies regarding the economic effect of AVs on society. There is a requirement of necessary policy and measurements which can pacify the negative effect and have a significant advantage of the revolution taking place.

1.4 Research Questions

As discussed in the research problem and objective section this study aims to answer the following research question.

"How might the introduction of autonomous vehicles influence the labor market related to potential changes in skills and job types in the Netherlands?"

To answer this research question, secondary research questions are formulated. The first secondary research question is obtained from a literature review of existing studies

SRQ 1: ***How did artificial intelligence and automation affect the labor market in the first world countries?***

The research study is based on the highest level of automation of AVs which is yet to be introduced on to the road. The AVs are manufactured by using AI and automation as one of the main technology. Hence it is important to understand how the previous technology like AI and automation has affected the employment status in first world countries. This literature can be extrapolated to predict the effect of AVs on the employment market in The Netherlands.

SRQ 2*: Which sectors might be affected by the introduction of the highest level of automation in the Netherlands?*

As the focus of the research is on AVs affecting the employment status, this depends on the type of sector being affected after the introduction of AVs. This sub research question helps to realize which type of sectors will be affected in the Netherlands.

SRQ 3: ***What kind of jobs might be in danger or emerge after the introduction of the highest level of automation in autonomous vehicles?***

From the above SRQ 2, we will get to know what sectors are being affected after the introduction of AVs. Along with that, it is also necessary to know what kind of jobs are at threat and what kind of jobs will emerge after the AVs are widely introduced into the market.

SRQ 4: ***How the skill mismatch factor plays its role in an increase or decrease in employment status after the introduction of new technologies like AVs into society?***

Skill mismatch has been everyone's talk since the economic crisis (2008-09). Certain enterprises could not meet the demand for skills required due to the change or advancement in technology. Hence this SRQ helps us to understand how the various types of skill matches such as skill shortage, skill gaps, skill obsolescence play their role in the effect of employment status after the introduction of the highest level automation of AVs.

1.5 Research approach

Every objective of research can be answered via three basic types of studies, namely exploratory, descriptive and causal study. An exploratory study is done when not much of the topic is known and it answers "why and how" types of questions. Whereas a descriptive study is conducted when the objective of the study is to collect data and describe the characteristic of the object. And the causal study is conducted when the objective of the research is to find out if the variables covary with each other (Sekaran & Bougie, 2016). From the above objective and the research question it can be seen that the effect of AVs on employment based on the skills and job types is the new phenomenon, this research study can be categorized as an exploratory study. The approach for this research is two-phase. Qualitative research and the literature review phase. This research on how the AVs' effect on employment based on skills and job types is empirically new. As of now, AVs are not yet introduced in society but testing has already been done by Waymo (Marr, 2018). Various reports by CEDEFOP and European commission have used quantitative methods on understanding by how much the employees have been affected. There have been reports on the effect on employment based on the adoption scenarios only. The reports are of quantified and based on the predictions. This research objective is more focused on how the highest automation level of AVs will affect the employment condition based on the skills and job types. **Hence the chosen method approach would be "qualitative research".**

The first phase of the research approach was carried out by conducting a literature review. This leads to a generation of conceptual models that show how the introduction of AVs will affect employment based on the terms of skill and job types. The model helps us to understand how the skill mismatch factor is dependent on new technologies like AVs. From this phase, it also gave an overview of which sectors might be affected by the introduction of AVs and also which kind of jobs will be in danger when the highest level of automation of AVs are publically accepted worldwide. Moving to the next phase of the approach, qualitative research was carried out by interviewing academicians in the field of the labor market, labor law,

transport and planning. The academicians were approached via-email after researching their publically available information. An individual email along with the research objective and research questions document was sent to the respective academicians. A total of 10 academicians with fields of interest mentioned above were interviewed. The data collected from the interview was systematically analyzed via coding and concluded the result in the result section. A detailed method of approach to the literature and interview is explained in Chapter 2.

1.6 Research framework

The research framework is used to form a bridge between the research question and the research objective. It is a schematic representation of showing the research objective and steps needed to achieve it. This helps the reader to understand the knowledge gap that is to be addressed and key domains where the required knowledge can be obtained which help in answering the objective (Verschuren et al., 2010). As suggested by Verschuren et al (2010), research guidelines are carried out and objectives are met categorically. And this is delineated in pictorial format, which can be seen in ***Figure 1***.

Chapter 2 describes the methodology. This chapter helps the reader to understand how the research design is carried out. As already explained in section 1.5 for indulging qualitative research as one of the methodologies for the research, this chapter gives a brief description of the interview approach. Also, it gives a description of how the literature review was carried out for the project.

Chapter 3 explains the theoretical background of the research using literature. This chapter helps to understand how technological innovation, skills and employment are dependent on each other from a theoretical perspective. It also helped to assess the previous research done on the subject. It helps to identify the knowledge gap in the study. This chapter aimed to understand how automation in the real world might affect employment and also how the labor market is affected or changes when a disruptive technology enters the market.

Chapter 4 details the analysis of the data. This chapter is mainly about the interpretation of the data acquired by the interviews conducted with the academicians and the experts. Steps involved in the analysis have been explained in detail. The three phases of the analysis, data reduction, data display and drawing conclusions are explained.

Chapter 5 is the discussion of the result and concluding them along with a future recommendation for the study.

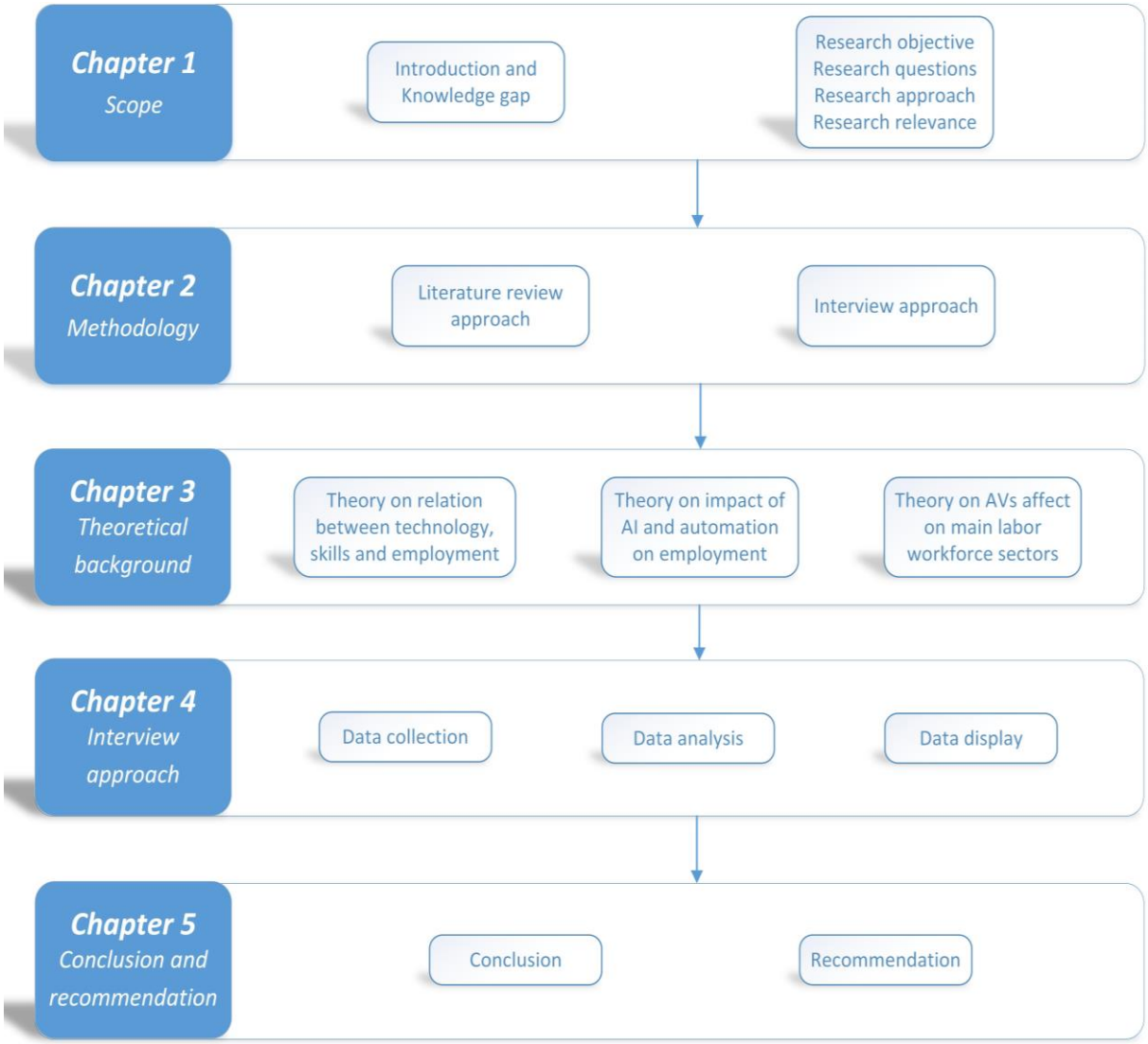

***Figure 1*:** Research Framework

Chapter 2: Methodology

This chapter gives a detailed description of the approach that has been taken to gather data for the research. As already mentioned in section 1.5, a thorough literature review and semi-structured interview were conducted. This chapter elaborates on the research design being adopted in the thesis. Section 2.1 explains the first phase of the research approach i.e. how the literature review was conducted. Section 2.2 explains how the interview procedure is carried and how the sampling is done for the project

2.1 Literature review approach

A literature review is defined as "the selection of available documents (both published and unpublished) on the topic, which contains information, ideas, data and evidence written from a particular standpoint to fulfill certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed" (Hart, 1998, as cited in Sekaran & Bougie, 2016 p. 51). The main purpose of conducting the literature review is to create a base for scientific research based on the theoretical perspective concluded by the previous research. A literature review for research is conducted to understand the core concepts of the topic based on the research objective and questions. Various outcomes were obtained by conducting the literature review. Some of them were defining the knowledge gap and relevance for the research. A conceptual model was generated, answering two of the sub research questions partially. Lastly, from the help of the literature, analysis (coding and theming) of the data from the interview was carried out.

For gathering literature, 3 scientific databases (Scopus, Science Direct and Elsevier) and search engine Google scholar were used. The first step was to find the literature on the relation between technology, skill and employment. The keywords such as "technology AND employment", "skills AND employment" were used. This resulted in 10000+ articles. Titles of the articles were scanned thoroughly based on the requirement needed for the project and this resulted in around 13 relevant articles. Later snowball sampling was used to extend the literature. The next phase of the research in order to understand the theoretical background of AVs on the economy of first world countries – the first step is to find how the employment condition was affected after the introduction of computers, artificial intelligence and automation. The first search string "Impact AND computerization AND employment" was used to find data on how the introduction of computers affected the employment condition. This yielded us around 9500 articles. On skimming through the titles of the articles, 17 articles were shortlisted. Among these articles one of the main articles by Frey and Osborne (2013) is considered to be based on predicting how susceptible jobs are. Similarly, the second search string "Impact AND automation AND employment" was used in Science Direct and Google Scholar, which yielded us around 7700 articles. After skimming through the titles of articles total of 15 articles was shortlisted. Among these many articles, a journal article named "Skills, Tasks and Technologies: Implications for Employment and Earnings" by Acemoglu & Autor

(2011) and “Automation, skills use and training” by Nedelkoska & Quintini (2018) was used to as a base for the study and via snow sampling, the literature was extended. To understand how the skill mismatch has affected the employment keywords like “skill mismatch”, “skill shortage”, “skill gap”, “over-education”, “skill obsolescence” was used. This resulted in 9 relevant articles. Journal article titled “Employment and social developments in Europe 2012” was taken as the base for understanding the components and dynamics of skill mismatch. Later via snow ball sampling from the reference of the relevant articles led to further lead in articles. And the final search string “Impact AND autonomous AND vehicles AND employment” on Google scholar was used to understand which all the sectors might get affected by introduction of AVs into the society. The article by Joint Research Center of European Commission titled “An analysis of possible socio-economic effects of a Cooperative, Connected and Automated Mobility (CCAM) in Europe” was used as base for knowing the industrial and service sector being affected. The next chapter gives the detailed results of the literature review. From the help of the literature, conceptual model was framed and then the interview process was started based on the questions generated from the conceptual model.

2.2 Interview approach

As stated in the research approach, two types of approaches were used for carrying out the research. The previous section explained how the literature review has been conducted. The second approach used for the research was by conducting semi-structured interviews. This section gives a detailed description of the structure of the interview.

The interview has been the most common method used for data collection in a research study (Alshenqeeti, 2014). There are currently three types of research interviews: structured, semi-structured and unstructured interviews. A structured interview is a process where the predetermined questions are framed and asked the interviewee. This type of interview will not be fruitful if the researcher is in need of “in-depth” information on the topic. The semi-structured interview consists of a few key questions and is a more flexible version of a structured interview. This type of interview is used for covering multiple areas and gathering “in-depth” information from the interviewee (Gill et al., 2008). The unstructured interview is also known as an open-ended interview, flexibility and freedom are given to both the parties (interviewers and interviewee). Unplanned questions will be framed on spot during the interview (Alshenqeeti, 2014; Jamshed, 2014). From the fact of the requirement of in-depth knowledge for the research and from the above definitions, conducting a semi-structured interview was the most suitable option for data collection. By employing this type of interview it was able to examine how the introduction of the highest level of AVs will affect the labor workforce in terms of skills and job types in The Netherlands, in a brief manner. The follow-up questions in the course of the interview helped to get ideas, insights and opinions of the interviewee and helped to form a storyline. Knowing the motivation behind choosing the semi-structured interview as one of the methods of data collection, it is also required to explain how the interview was structured, how the respondents were chosen and what were the questions asked to the respondents.

2.2.1 Interview structure

Figure 2 shows the pictorial representation of the interview structure. The first step of the interview process was to collect the theoretical perspective and information from the literature and generate the conceptual model. The second step was preparing interview questions; this was done by using the conceptual model generated from the literature. The interview questions also corresponded to data found from the theoretical perspective. The third step was to find the right type of candidates for the interview. This was done with the help of a sampling design. Candidates for the interview were academicians from the university in the Netherlands and experts from the labor organization of the Netherlands. A more detailed method of choosing the type of respondents with the help of sampling design for the research is explained in the next section. Fourthly the individual emails were sent to each of the candidates. The email stated the research objective and questions to give a brief idea about the project. Fifthly, for the candidates who agreed on giving the interview, the interview was conducted based on their convenience of time and place. Totally, 13 individual interviews were conducted. Out of which 7 were face to face interviews at the interviewee's workplace, 3 were via Skype call and the remaining 3 candidates agreed to write in their answers via e-mail due to their unavailability for face to face interviews. Sixthly, the recorded interview was transcribed using the online software called ***"Otter.ai".*** It is a free online software. The same transcribed data was made into a report document and sent back to each interviewee, to ensure if they agree to what they told during the interview was true. The detailed interview report can be seen in ***Appendix 3.*** The data obtained were then analyzed through coding, a detailed explanation of the analyzing the data can be found in ***Section 2.3.3***. These analyzed data are shown in the form of results in ***Chapter 4***.

Before starting the interview with the respondents it was necessary to follow standard interview protocol with each respondent to get the necessary data without hassle-free. These protocols are stated below.

- Research objective and research questions were e-mailed to each candidates so that the candidates are familiarized with the research topic during the interview
- After the candidates agreed on giving an interview, a consent form was given to each candidate, which stated that the results will be published anonymously and the interview will be recorded and transcribed for the research project.
- Each interview started with an introduction session, research objective and questions were explained to each of the candidates and asked if they had any queries to be clarified before asking the interview question
- At the end of the interview, the respondents were asked if they had any queries and their final conclusion on how the AVs will be affecting the labor workforce

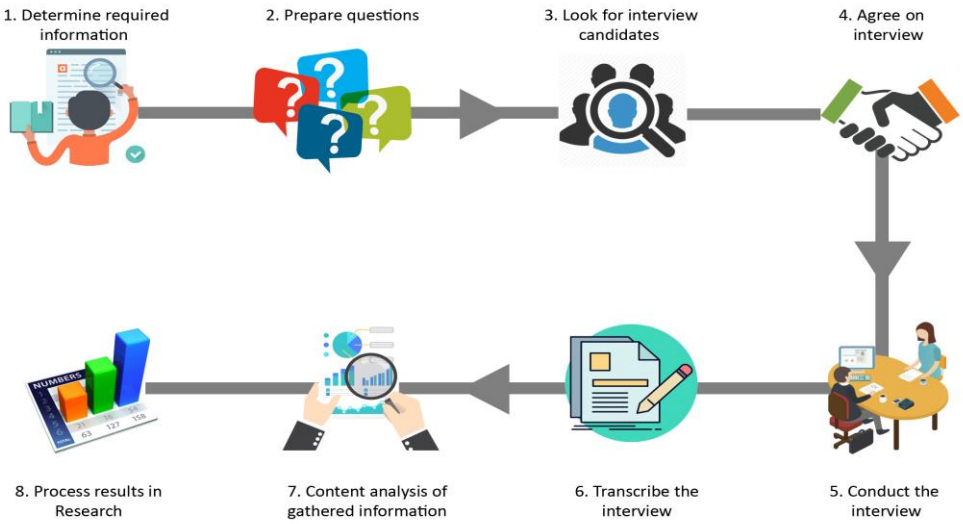

Figure 2: Steps involved in interviewing

2.2.2 Sampling and respondents selection

"The process of selecting the right individuals, objects, or events as representatives for the entire population is known as sampling" (Sekaran & Bougie, 2016, p.235). It is necessary to select the right type of elements from the population for the data collection. Else the collected data will be biased if the respondents are not familiarized with the topic (Sekaran & Bougie, 2016).

Nonprobability sampling technique was used in this research as the probability of picking from the population is unknown; this led to findings that were found from the study that could be generalized to the entire population. Instead of picking the elements which are conveniently available, for this research, it is necessary to pick elements and obtain information from particular target groups. Hence, the most suitable process will be by purposive sampling. As per the research objective, it is necessary to get information from the experts who are in the field of labor markets, transport and artificial intelligence. The sample unit who were expertise in these topics was chosen as they are closely related to the emergence of AVs and its implication on employment. Hence, the best approach was to adapt to judgment sampling. By adopting judgment sampling, individual emails were sent to each academician of different universities situated in the Netherlands. 32 academicians were shortlisted for the research purpose by viewing their individual profiles on their university websites. Out of which only 12 academicians accepted the invitation and agreed to give the interview. Due to confidentiality agreement between the researcher and interviewee on maintaining anonymity, the information on academicians such as name, designation or the university where he/she is working, will not be disclosed. Later, experts from the labor organization of the Netherlands were contacted. One expert agreed to give an interview and share the information for the research. The interview was taken place in the workplace. The final sample consisted of 12 academicians from universities of the Netherlands and 1 expert from the labor organization of the Netherlands.

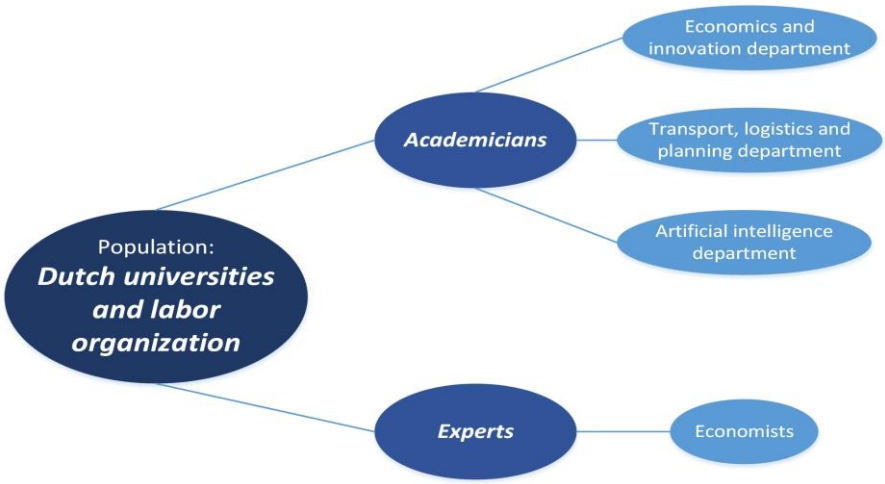

Figure 3: Sampling design used for the research

Table 1: Profile of interviewees used for research.

Code	Role	Department
ICA	Academician	Economics and Innovation (E&I)
ICB	Academician	Economics and Innovation
ICC	Economists experts	Labor organization
ICD	Academician	Transport policy
ICE	Academician	Transport and planning (T&P)
ICF	Academician	Transport and planning
ICG	Academician	Artificial intelligence (AI)
ICH	Academician	Artificial intelligence
ICI	Academician	Transport and planning
ICJ	Academician	Transport and planning
ICK	Academician	Transport and planning
ICL	Academician	Transport and planning
ICM	Academician	Transport and planning

2.2.3 Interview questions

Interview question was the main source for answering the SRQ 3 and thus helping to connect the dots with all the SRQ to answer the main research question. The interview questions were separated into two parts, ***Part A*** and ***Part B***. Part A consisted of a questionnaire which was asked in the form Likert scale on a scale of 1 to 3. ***1 - Agree, 2 – Neutral, 3 - Disagree***. This type of scale is used to check how the respondents agree or disagree with the statement. Since the questions were asked in the rating scale and not in descriptive type. A common reason for asking the questions was to compare the scores of each of the respondents on how they agree, neutral or disagree with the proposals tabulated in ***Table 2***. The questions asked during the interview of Part A are stated in ***Table 2.***

__Table 2:__ Part A interview questions.

Sl No.	Statements/Proposals
1	After the introduction of the highest levels of AVs, skill mismatch is one of the main factors which affect employment in the labor workforce
2	Skill mismatch will be a barrier between the employers and employees after the introduction of AVs of the highest level of automation
3	After AV adoption, skill mismatch in the labor workforce is a short term period problem
4	After AV adoption, skill mismatch in the labor workforce is NOT a long term period problem
5	Skill mismatch will be a huge concern in The Netherlands after the introduction of AVs
6	The effect of skill mismatch on labor workforce is similar to each level (0 to 5) of automation of AVs
7	There will be resistance from workers in the traditionally low skilled industry after the introduction of AVs

The second part of the interview questions was asked in the pattern of a semi-structured interview. The interview questions were mainly focused on The Netherlands. The questions asked to each respondent are stated in ***Table 3***.

__Table 3:__ Part B interview questions

Sl No.	Questions	Reasoning
1	To what extent do you agree that skill mismatch will be one of the main factors affecting employment in the labor workforce?	To understand if only skill mismatch has been or will be a major threat to the labor market in The Netherlands.
2	Is the skill mismatch factor similar in all the countries or will it differs from country to country and why?	This question was asked to know how the Netherlands as a country is different from other countries when considering skill mismatch as a dependent variable to the labor market

3	Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?	From literature (Chapter 3) we will know which type of sectors might be affected by AVs in general. This question gives an answer to, which labor workforce that might be benefited or not benefited in The Netherlands
4	Which type of skill mismatch would result in the above-mentioned industries due to the introduction of AVs of the highest level of automation?	To understand which type of skill mismatch might be a major issue in The Netherlands after the introduction of AVs of the highest level of automation.
5	Why is it similar or different for each labor workforce?	This question was asked how it differs from each workforce and why does it occur
6	How will the skill mismatch factors affect the labor workforce after the introduction of AVs of the highest level of automation?	To understand how differently the skill mismatch increases or decreases with each level of increase in automation of AVs
7	Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?	
8	To what extent do you agree that the skill mismatch problem is only a short term problem or will it be a long term problem?	As a technology being developed, it will always take time to get itself adopted into society. This question was asked to understand after the introduction of AVs will it also follow the same path similar to other technologies or will it different adoption cycle.
9	Will, there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?	As a technology, it always has pros and cons among various skilled labor workforces. This question helps us to understand if AVs are accepted by everyone in the labor market.
10	How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?	AV is a novel concept. As one of the main stakeholders of technology adoption in society, the government plays an important role in the amendment of policies on technology. These policies will help in the widespread of this technology.
11	Apart from policies introduced by the government, what other measures that employers (firms) could implement to mitigate the skill mismatch due to AVs?	As one of the main stakeholder and technology innovators, employers play an important role in adopting the technology and increase the output by training more laborers.

2.2.4 Qualitative data analysis & technique

After transcribing the data from the interview, data processing and analysis were carried out. As one of the main methodologies of the research was conducting an interview (qualitative research) with academicians and experts, the data contained an immense number of words rather than inform numbers. Sekaran & Bougie (2016) claim that qualitative data analysis is not easy, compared to quantitative data analysis as there are very few established and accepted guidelines for analyzing qualitative data. Miles and Huberman (1994) came up with a method for analyzing the data, which is widely used to date. The method contains three main steps namely, data reduction, data display and drawing conclusion. These steps are iterative and cyclical. During the initial phase of the analysis, new insights and ideas are generated which are used as feedback during the phase analysis. ***Figure 4*** shows the schematic representation steps involved in analyzing data.

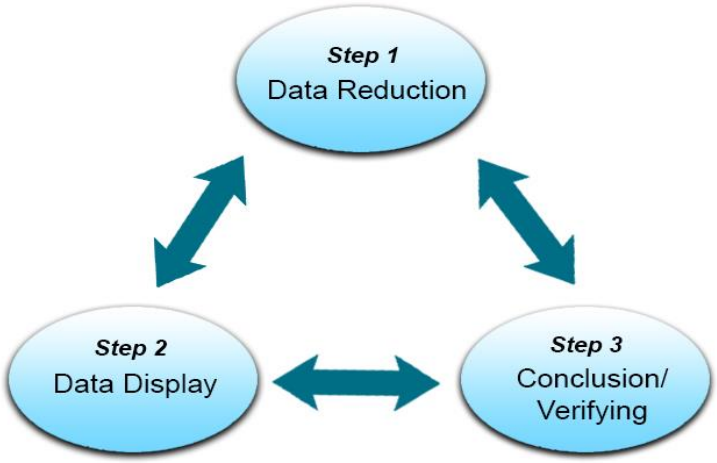

***Figure 4*: Data analysis process**

Data reduction

As we already know that the qualitative data provides an immense number of data, the first step would be the reduction of these data through coding and categorization. Coding is defined as the "Analytic process through which the qualitative data that you have gathered are reduced, rearranged, and integrated to form theory" (Sekaran & Bougie, 2016, p.334). This helps in drawing a meaningful conclusion. In a qualitative study, there are three different approaches that can be used for coding. They are a tight approach, grounded theory and middle-ground approach. The tight approach is a process in which there are already predefined codes and does not allow the researcher to improve the code list after the data analysis. The grounded theory approach is done by forming codes from the collected data. It is the high-risk process as it does not provide a clear understanding to the researcher what to look for. And finally, the middle-ground approach is the process in which there are already pre-defined codes from the theoretical perspective and the list of codes is developed in a later phase of the analysis. As this research is the exploratory study, the middle-ground approach would be the most suitable approach for coding techniques during the phase of data reduction.

From the interview questions asked to the respondents, the data reduction process can be categorized into two main themes i.e. i) Planning for unavoidable conditions ii) Change in occupation and industries. Various categories were formed in each theme which is discussed in the next paragraph.

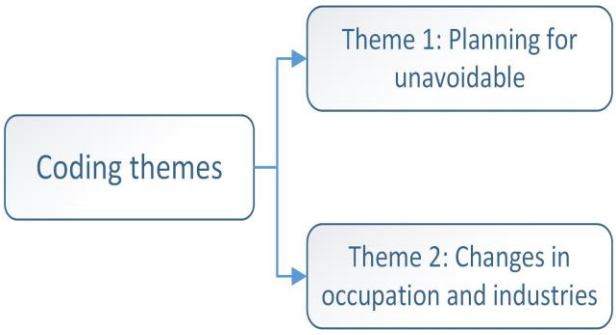

Figure 5: Themes used in coding

In the data reduction process, the coding process was done in two phases. In the first phase, coding was performed on the transcript line by line (Miles et al., 2013, Chapter 4). The first phase had two types of coding approaches. The first coding approach was by "Deductive Coding" (Miles et al., 2013, p. 86). This means that we started with an initial list of codes that were derived from a theoretical perspective and literature review. This process was carried out to avoid a false start. An example of a deductive approach used on the transcript can be seen in ***Figure 6.***

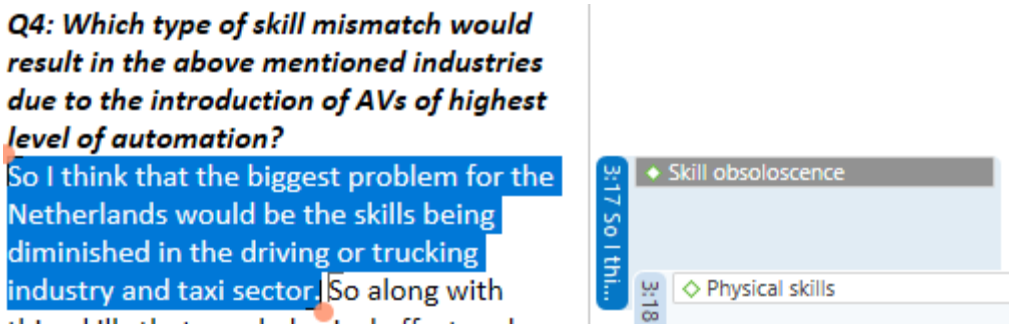

***Figure 6*:** Sample of interview transcript using deductive coding approach in ATLAS.TI

The second step in this phase was the "Inductive approach" (Miles et al., 2013, p. 86). This approach was done progressively during the data collection. New codes emerged as the data was explored further. This avoided force-fitting codes with the existing codes. This process involved labeling phrases, sentences with a word or phrase. The process of labeling phrases was carried on the basis of the repetition of thoughts/ideas and similarities with the content from the literature. This phase of coding consisted of 83 codes. These lists of codes can be seen in ***Appendix 2***. An example of the inductive coding approach used on interview transcript where the interviewee explains the other main factors also affects the employment condition after the introduction of AVs can be seen in ***Figure 7.***

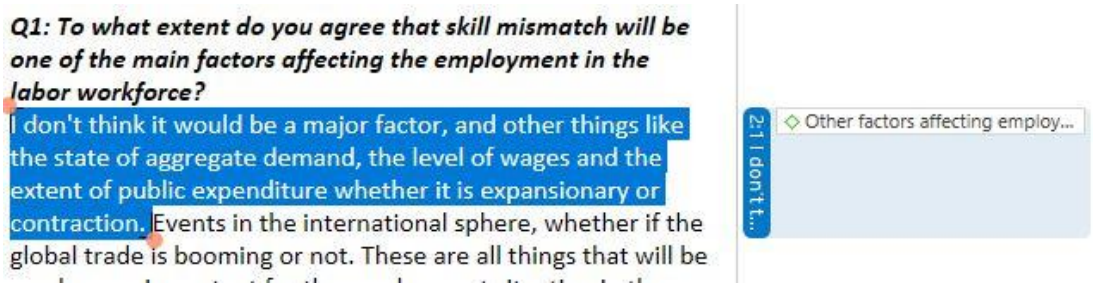

Figure 7: Sample of interview transcript using the inductive coding approach in ATLAS.TI

The second phase of the coding process was performed via axial coding. Axial coding helps in minimizing the differences between the codes by connecting them into one category of codes. It was important to find the balance between the general code and specific codes, which led to the generation of abstract code. A visual example can be seen in ***Figure 8.*** In this example code category *(Skill mismatch effects)* was generated from the literature study and theoretical perspective. The detailed codes *(skill demand and skill supply)* are the first order codes that were generated by using an open coding approach which was explained in the previous paragraph. Then second-order codes were formed by merging the first order detailed codes. In this example, the aspect of skill supply and skill demand used by the interview was termed as an *imbalance between skills.* This approach was implemented to make a list of codes simple and well ordered.

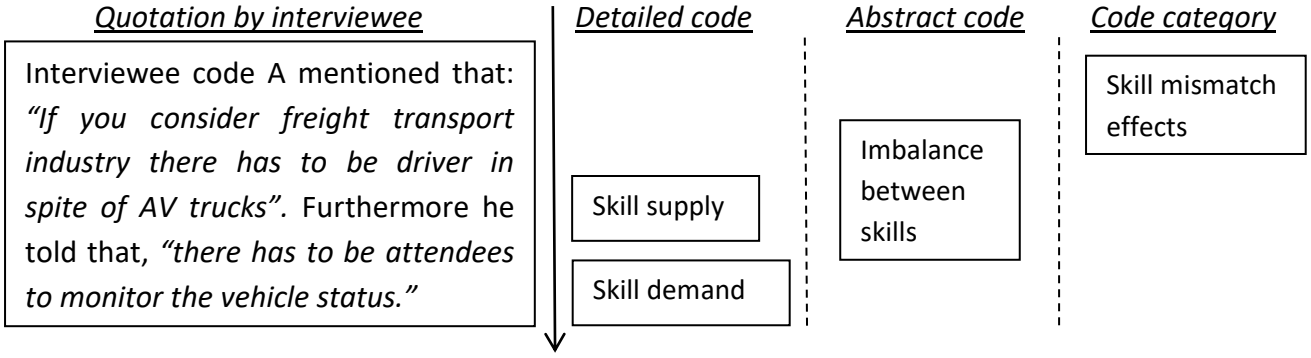

Figure 8: Axial coding approach for the interview reports

The categories generated by using the above approach led to the formation of six categories. These categories can be further tabulated under themes. This can be seen in ***Table 4.*** It also gives an overview of which categories will fall under which themes.

Table 4: *Categories used for coding*

Theme 1: Planning for unavoidable	**Theme 2: Change in occupation and industry**
Introduction of AVs **(IAV)**	Winners and losers of AVs **(WLA)**
Skill mismatch effects **(SME)**	Resistance from labors **(RL)**
Skill mismatch duration **(SMD)**	
Involvement of government and employers **(IGE)**	

Data display

After transcribing the interview from all the 13 interviewees, it resulted in a large number of codes or factors (83 codes in total). Hence it was necessary to adopt an appropriate display method. It was decided to display the data with the help of a combination of tables showing mean, standard deviation values for the PART A of the interview and also by using bar graphs showing a frequency of interviewees rating. For PART B of the interview, data was again displayed by the help of tables which showed the frequency of codes used by interviewees and some parts of the interviewee quotes are displayed. The tables provided an overview of data but motivation and insight of the interviewee were not displayed. Therefore, it was decided to complement them with quotations in this report.

Drawing/verifying conclusion

The conclusions have been drawn based on the huge volume of the data from the interview with academicians and the expert. It is a challenging task to draw conclusions from huge volume of qualitative data which is obtained from the interview. Most important task of the conclusion is to provide an answer to the main research question. The objective was to provide a strong, brief and concise answer while being clear and precise. Coding helped to provide structure in the data and to generate a helicopter view of the data. This perspective was used to provide an answer to the main research question and to critically discuss the findings in Chapter 5.

Chapter 3: State of the art and building conceptual model

3.1 Introduction

To understand and to get a broader idea of the topic in hand, it is necessary to review the recent development on the topic. The following four sub-chapters are used to answer the sub-questions which are asked before. The second subchapter tells us about what are Autonomous vehicles, gives an overview of the technology used and what is the feature of the maximum level of automation i.e. Level 5 automation. The third subchapter shows us the relation between technology, skill, and employment. The fourth subchapter helps us understand past technological progress such as development in automation and artificial intelligence effect on employment in first world countries. The fifth subchapter will cover the various economic sectors which might get affected by the adoption of AVs. And finally, the sixth subchapter helps us to frame the theoretical framework.

3.2 Autonomous vehicles

A vehicle that can operate independently without any human interaction is called Autonomous vehicles (AVs) (Fagnant & Kockelman, 2015). The idea of AVs was envisioned back in 1939 by General Motors and they made a concept named “Futurama” at the World’s Fair (Spulber & Wallace, 2016). AVs' future has been mostly dependent on technology development, government support, social acceptance and regulation. There are some key technologies behind the development of AVs and they are Artificial intelligence, Human Machine Cooperation, 5G mobile, Telematics and Light Detection and Ranging (LIDAR) (Cutean, 2017). As we already know from the introduction about the benefit of the AVs, it is necessary that these environmental, mobility, safety benefits emerge successfully with cooperation between various stakeholders like regulators, vehicle manufacturers and the public. To bring clarity and consistency between these stakeholders various levels of automation were created by two distinct organizations namely, National Highway Traffic Safety Administration (NHTSA) and Society of Automotive Engineers (SAE) (CCMTA, 2016; NHTSA, 2013). These various levels are discussed in the following section.

National Highway Transport Safety Administration (NHTSA) claims that the vehicle ranging from an automation level 0 to level 3 requires a human driver. But, from level 4, the vehicle is in no need of the driver. Hence, Miller (2015) argues that there will be a huge impact on employment significantly at level 3 of automation itself. Two organizations namely NHTSA and Society of Automotive Engineers (SAE) classified the level of automation for autonomous vehicles. NHTSA classifies to five levels (0 - 4) whereas, SAE classifies it as six levels (0 – 5). To avoid confusion in this report, classification done by SAE i.e. (0 – 5) levels are considered. A brief explanation of the level of automation is explained in the next section. This thesis will be focusing on understanding the effects of jobs and skills for the highest level of automation i.e. level 5 in the industrial and service sector.

3.2.1 Levels of automation

The following definition covers the range of vehicle automation from no automation (level 0) to fully automated vehicles (level 5). The SAE has segmented into five levels, which are stated below.

Table 5: *The five-level of driving automation (Source: (CCMTA, 2016))*

SAE level	Name	Narrative Description	Execution of Steering and Acceleration / Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
The human driver monitors the driving environment						
0	No Automation	The whole vehicle control system (braking, steering, and throttle) is solely controlled by the driver alone. The driver will be solely responsible for monitoring his driving environment. The vehicles are designed with certain driver the convenience which warns the driver about the forward collision, wipers, headlights, etc.	Human driver	Human driver	Human driver	N/A
1	Driver Assistance	Automation at this level is function-specific controls. They operate independently from each other. The driver will be in control of the vehicle and will be solely responsible for the safety of the vehicle and environment. The vehicle may be designed with multiple features such as adaptive cruise control, dynamic brake support in an emergency.	Human driver and the system	Human driver	Human driver	Some driving modes
2	Partial Automation	Automation at this level is designed to function with two specific primary controls to work in unison with the driver. The system can renounce the function without any advance warning and hence drivers should always be attentive during driving.	System	Human driver	Human driver	Some driving modes
Automated driving system("system") monitors the driving environment						
3	Conditional Automation	Driver, driving this particular level of the automated vehicle can cede complete control of the vehicle. But only in certain traffic conditions or environmental conditions. The driver should be available to take over the control of the vehicle occasionally.	System	System	Human driver	Some driving modes

4	High Automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene	System	System	System	Some driving modes
5	Full Automation	The final stage of automation where the vehicle completely takes over the safety-critical driving function and monitors the environment and roadway conditions for the entire trip. The safety of the vehicle is solely dependent on the automated system	System	System	System	All driving modes

From the above section, it can be seen that there are many advantages and also disadvantages. According to literature, the introduction of AVs and its effect on employment is considered to be a disadvantage. From the history of the technology or industrial revolution, it is a common gesture, where one takes when a new technology has been introduced into society. Since we are studying a technology that is yet to be fully adopted by society, we cannot conclude that AV as a technology will be having a negative effect on employment. There is still debate going on this topic. This field of research is yet to be explored and there are very few conclusive data available to procure the claim. As already mentioned in the introduction there have been only a few countries who have done certain research on the effect of employment due to the introduction of AVs. There is yet to be research done focusing on The Netherlands on how the AVs will be affecting the labor market based on the skills and job types. Further sections in this chapter discuss the state of art and selection of an appropriate research lens or theoretical perspective which can be helped in building the conceptual model. This theoretical perspective and a conceptual model was used as the main input for the interview question.

3.3 The relation between technology, skills and employment

Discussions about the interdependency between technological innovation and employment have been dated back to the 19th century (Vivarelli, 2014). This interdependency has created an immense amount of benefits along with undesired disruptions which are evident from the history of the industrial revolution (Frey & Osborne, 2017). From the past, economists believed that the improvement in technology can lead to better output and lower cost per unit with the usage of existing sources. However this may have not worked out for all the periods of time, but it is believed that it has been smooth at the macroeconomic level (Koutroumpis & Lafond, 2018). Along with this, they had disbelief and fear that technological advancement would displace workers and give rise to unemployment (Arntz et al., 2016). The following section helps us to understand the relation between technology and employment. And in the latter subsection, the reader gets to know the relation between skill and employment.

3.3.1 Technology and employment

The ever-changing needs of society have put the technology in the driver seat. Relationships between society and technology have been co-influence, co-production and co-dependence (Santoso, 2016). Technological innovation progress from the past three industrial revolutions has witnessed a shift in the workforce. There have always been two particular views on the impact of technology on employment. One is technological innovations always leading to economic growth, greater productivity, job growth etc. This leads to better products and increases in consumption and hence, growth in the market and job growth. On the other hand, technological innovation is leading to greater and better products but it is taking away jobs from the laborers on a huge scale. Thus leading to a decrease in consumption and lower purchasing power and hence recede in profits and markets (Est & Kool, 2015). It has been seen from history that the change in technological innovation or employment enhancing is accompanied by the development of new skills. Operating or understanding new technology requires the development of required skills (Autor et al., 2015; Castro Silva & Lima, 2017). Additional or new employment leads to increased consumer spending; this benefits other businesses or working organizations. This leads to positive money flow in the marketplace and hence healthier overall economy in the society. But if unemployment increases, people tend to spend less, leading to lesser consumer demand (Lister, 2019). Technological innovation is one of the major factors which contribute to the employment condition of society (Avenyo et al., 2019; Nübler, 2016; Santoso, 2016). Cardullo & Ansal (1997) developed a model that illustrates the interaction of new technology or innovation with jobs. Cardullo & Ansal claim that the technology is bound to create job displacement but in addition, it is also responsible for creating extra additional jobs thus compensating the displacement. They claim that it has all been in history that these displacements are temporary and as the capacity adjustment checks in the demand are increased. This makes Cardullo & Ansal claim that the technology impact has always been positive on employment.

According to Frey and Osborne, about 47% of replacement jobs are due to the rise of automation alone in the US, here (Frey & Osborne, 2017) has only considered the negative effect of the rise of machines. However, authors like Bonin and (Arntz et al., 2016) predicted that there will eventually be fewer jobs lost due to technological advancement. Here, they have considered the task and skills availability for jobs rather than the occupation itself. Evidence has shown that, as technology progressed it has given rise to economic inequalities. The difference, shortage and gaps in skill between the companies have led to an individual company to monopolize wages in the labor market, which in turn gave rise to unemployment at the lower end (Santoso, 2016). This has often led to skill mismatch among the employers and employees. Eventually, this has created pressure on individuals to get updated according to the new skills and tasks which are in demand. Detailed explanation of skill mismatch and its relation with the employment is discussed in the next section.

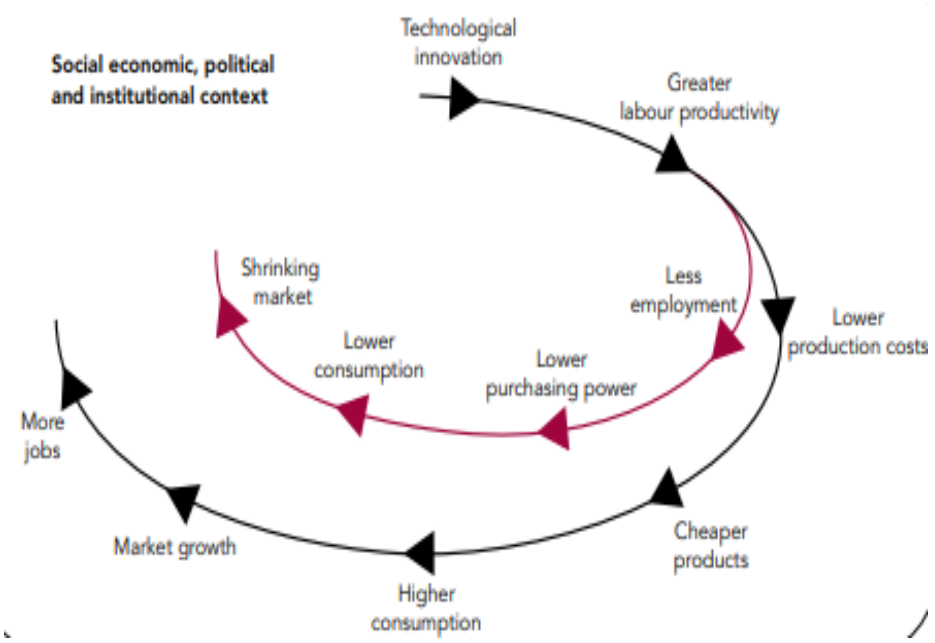

Figure 9: Relationship between technology and employment (Source: Est & Kool, 2015).

3.3.2 Skills and employment

"Despite the enormous interest in how skills in Britain have changed over time, how they are distributed, and how these trends and patterns compare with competing nations, there is surprisingly little agreement on what 'skills' actually refer to" (Abdel-Wahab et al., n.d.; as cited in Felstead et al., 2002 p. 20). Skill can be defined as qualification, ability to perform specific occupational tasks. As we mentioned previously that as technological innovation leads to greater labor productivity, there are many kinds of literature that show the linkage between the skills and labor productivity too, which leads to an effect on employment. There are five main drivers which drive productivity but skill is identified as the main driver of labor productivity (CEDEFOP, 2015a; Gambin et al., 2009). With the right type of skills, people can work with confidence and to their full potential. Skill determines the competitiveness and capacity to drive innovation. Hence they act as a catalyst in the creation and growth of jobs (European Commission, 2016). As per the report from (World economic forum, 2016) the training and labor market institutions are taking longer periods of time to develop skills for the new trend of technology. They argue that 50% of the knowledge that the students learn in their 4-year degree curriculum gets outdated when they are out searching for jobs. Skills are not time friendly; it changes or gets improved. Some might get obsolete and some emerge as the new technological innovation emerges in society (Abdel-Wahab et al., n.d.). Displacing effect and employment enhancing technology has accompanied with a change in the composition of skills required by the labor force (Castro Silva & Lima, 2017). People are accustomed to different levels of skills and training leading to contribution towards innovation at different levels. Recent empirical research shows us that employees with enhanced skills and training and constantly working on innovation processes can make the firm produce new innovative product and market novelties (Dachs et al., 2018).

There are many pieces of literature that show the quantitative impact of technology on employment, but there is also some literature that shows us the qualitative aspect of the relationship between employment and technology. By the evidence from history, it can be seen that technology is biased to certain groups of workers who are dominated by the skill and tasks which they have to perform. This gave rise to a notion called Skilled Biased Technological Change (SBTC) (Srour et al., 2013; World trade report, 2017). SBTC leads to an increase in employment and wage for skilled workers, whereas depletion of employment for unskilled workers. This was all dependent on the direction of technological advancement (Bartel & Sicherman, 1999; D'Orlando, 2019). However, Goldin and Katz claim that the skill bias was not of much influence towards manufacturing industries but was giving skill complementary effects to society in the early twentieth century (World trade report, 2017). From the Labor Force Survey by EUROSTAT, it is seen that skill development is based on the education level at which the employees are educated. The survey shows us that unemployment is high among the people with primary and secondary education compared to the people with tertiary education levels (Dachs et al., 2018). SBTC was the main reason for the change in wage structure during the early '80s, where skilled workers paid more and less for unskilled workers. However Bartel & Sicherman (1999), argues that the change in wage structure is not due to the SBTC but indeed because skilled workers sorted themselves out in the high tech firms and thus commanding higher wages (Castro Silva & Lima, 2017). Apart from creating bias in skills, technology also caused lower demand for skills. Evidence shows that in the United States the highly skilled workers performed occupations that were usually executed by low skilled workers resulting in a deskilling process. This process makes the demand for cognitive tasks much lesser than it was required in the initial phase of adoption of the technology. Hence crowding out the low skilled workers even further down the occupational ladder and taking away their jobs (World trade report, 2017).

3.3.2.1 Skill mismatch

From decades there have been skill imbalances, where there has been an increase in demand for high skilled workers and lowering the demand of low skilled workers. This has led to the **Skill mismatch**. Skill mismatch is defined as an employer not able to find the right talent or candidate with the suitable talent to do the particular task given by the firm (CEDEFOP, 2015b). "If the growth of educated supply outstrips demand, this may be reflected in a surplus of skilled workers in terms of unemployment, but also in workers who are overeducated for the jobs they perform" (CEDEFOP, 2010 as cited in ILO, 2014, p. 5). McGowan & Andrews (2015) claims that the skill mismatch can be shaped by two particular factors i) individual and workplace characteristics ii) a policy environment that reduces distortion to labor mobility. These concerns have been dated back to 1970. Mismatch arises when there is a skill gap due to technological advancement. According to the European working condition survey (EWCS) more than half of the EU workers are not matched or fit for their current job. It is seen from the survey that the workers are over skilled and are capable of handling complex tasks. However, there is a fewer number of under-skilled workers with the required skills (CEDEFOP, 2015a). Skill mismatch has been a serious concern since the following global economic crisis which

happened during the year 2008-2009. The crisis led to an increase in unemployment, patterns in job creation and job destruction (ILO, 2014). Skill mismatches have negative consequences upon various individuals, society, employers as a whole. This demotivates and lowers the job satisfaction and self-confidence of an individual. On the other hand, employers undergo a loss in productivity and have to bear high recruitment costs (CEDEFOP, 2015a). Level and type of education influence the mismatch of entering employment. Insufficient training, skilled biased technological progress for the employees gives space for shortage in skills leading to skill gap and skills mismatch (CEDEFOP, 2010).

It can be seen from the above paragraph that the skill mismatch is the outcome of the complex interaction between the skill supply and demand when a new technology has been introduced to society. To keep a good relationship between the supply and demand of skills, employers take multiple measures like feedback mechanisms and interactions. To avoid the skill shortage for the short term, often employers hire low skilled workers and train them, as they cannot pay a higher wage rate for the high skilled workers. Whereas in the long term employers change the strategy with the recruitment process and invest in a different mix of capital, labor and technology (European Commission, 2012). Skill mismatch has certain components and dynamics which can be seen in ***Figure 3***.

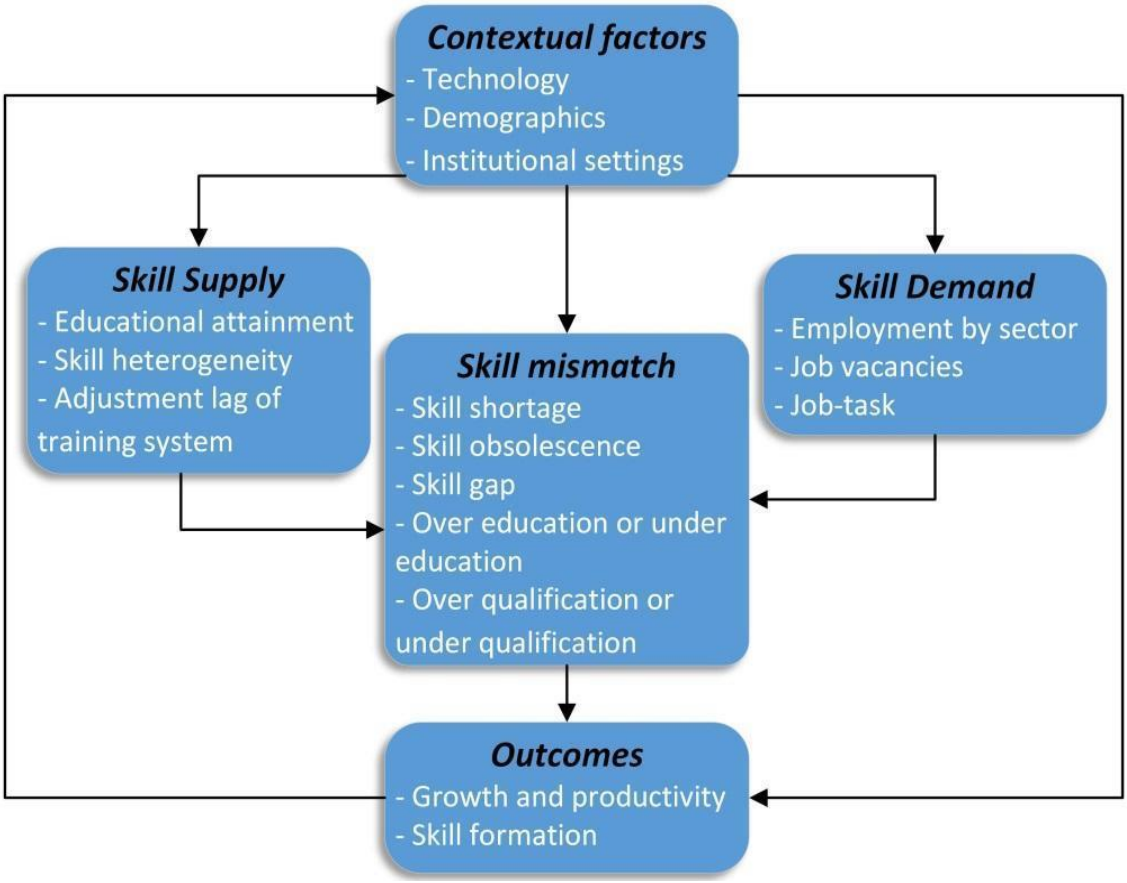

***Figure 10*:** Components and dynamic of skill mismatch (Source: European Commission, 2012).

Skill demand side includes major factors such as globalization, job vacancies due to technological change, and lag in the adjustment of recruitment of right skilled employees and also by the institutional factors (e.g., employment protection). The rise in the skill demand when a new technology being introduced can be related to the hypothesis of SBTC mentioned before (Green, 2016; Nedelkoska & Quintini, 2018). Apart from creating demand from technical change, consumer's preferences also play an important role in creating skilled labor demand (Després et al., 2018). Currently, there has been a huge demand for skilled laborers due to the accelerated adoption of AI and automation which has given rise to the various machine to machine interaction devices. This has resulted in a demand for laborers who are specialized in computing and related ICT skills (Industrial strategy council, 2019). Apart from the increase in requirement of technical skills, there has been also demand for basic and high cognitive skills, physical and manual skills, social and economic skills (Bughin et al., 2018)

The cause of imbalance from the skill supply side would be adjustment lag between the current trend and the educational institutions or training system. Also, certain people lack geographical and occupational mobility to enhance their skills and get updated to the current trend. Hence there is a requirement for educational institutions to be well known with the current trends and technology so that they can encourage students and young professionals to choose the right career choice (European Commission, 2012).

There are few frequently examined skill mismatches around the world which can be termed as skill shortage, skill gaps, skill obsolescence, over education or under education and overqualification or over education. These terms have their own relation, consequences and how they manifest with the employee and employers. Some of the mismatches can be related to employers and difficulties faced at the firm level, whereas some of them can be related to employees (McGuinness et al., 2017).

- ***Skill obsolescence:*** This is defined as the process in which an employee's skill becomes obsolete. This can be caused due to the aging of manual skills through technological development or change (McGuinness et al., 2017; Santoso, 2016). Skill obsolescence often leads to skill gaps. In literature, authors have distinguished skill obsolescence into two types, one is technical skill obsolescence and other is economic skill obsolescence. Technical skill obsolescence occurs when there is a deterioration of physical and mental capacities due to illness, aging or injury. Economic skill obsolescence occurs when there is a new technology that has been introduced into the market (CEDEFOP, 2010; McGuinness et al., 2017).
- ***Skill shortage:*** Skill shortage is caused due to underinvestment in the training of employees from the employers (CEDEFOP, 2010). ILO (2014, p.) defines a skill shortage as "the demand or supply for a particular type of skill exceeds the supply or demand of people with that skill." The measure for skill shortages is usually measured at the firm level, hence affecting the firm productivity. To mitigate this problem firms respond by improving the efficiency of usage of the core workforce (McGuinness et al., 2017). There

are certain reports which state due to skill shortages the productivity decreases due to unfilled vacancies. However, not all the empirical evidence gave the same result. McGuinness and Bonner (2002) found no evidence that the unfilled vacancy led to a decrease in productivity.

- ***Skill gaps:*** ILO (2014) defines skill gaps as the imbalance in the level of skill which is required to adequately perform the job. The literature argues that under skilling and skill gaps are similar and they highly correlate with each other. These gaps can only be filled or eradicated by training sponsored by employers. Also, one more measure that can be taken to minimize the gap is by providing incentives to the employees or trainees for upskilling (CEDEFOP, 2010). Due to the factor of skill gaps, one-fifth of the firms believe that emergence and adoption of new technologies are delayed. And one-third of the firms believe that the skill gap is one of the barriers to the adoption of a new work format in the firms (McGuinness et al., 2017). Skill gap duration solely depends on how soon the individual in the firms is retrained to relevant skill areas, the overall cost involved in the training. If the individuals are in the tier of advanced skills, the duration of minimizing the effect is much lesser than compared of individuals with general and intermediate skills (CEDEFOP, 2010).
- ***Over education or under education:*** This can be defined as the education level of the employees will be more or less than the required for the particular job (ILO, 2014). An increase in overeducation leads to cost to individuals, the firms and the economy (McGuinness, 2006). Diem (2015) claims that due to this type of mismatch there have been negative consequences on the individuals such as they earn a lower income than the individuals who have the occupation matched to their education. Apart from this, there are possibilities that the overeducated workers will be liable for the non-transitory cost. Also, the overeducated workers push down the undereducated workers, replacing them and increasing the mean educational level in the workplace (McGuinness, 2006).
- ***Over skilling or under skilling:*** Over skill is defined as the situation in which an individual cannot completely utilize his/her skills. Whereas, under skill is defined as the situation in which the individual lacks skills to perform the task at the current job to acceptable standards (CEDEFOP, 2010). Research on over skilling persistence is much more limited as panel data on over skilling in Europe are lacking. Shreds of evidence show us that the maximum people affected by this factor is mainly people who are early school leavers from general education and very less among university graduates. It also shows us that there is a wage penalty among skilled and under-skilled individuals(McGuinness et al., 2017).

3.4 Past technological progress effect on the labor market

There has been a constant debate from the era of the first industrial revolution which can be dated back to the 18th century about how technological progress causes long term unemployment (D'Orlando, 2019). From the past there have been constant concerns over technological progress and (Mokyr et al., 2015) claims it is due to the three major concerns.

One of them being the most common concern is constant progress in innovation or technology could lead to unemployment. Many other authors like (Autor et al., 2015) support this claim by highlighting other consequences like rising polarization of labor market outcomes, growing inequality and changing skills demands.

Currently, mankind is on the verge of the fourth industrial revolution and the list of new technologies grows every day. Out of which the major technologies like artificial intelligence, robotics, quantum computing, data science plays a prominent role in the development of advanced applications such as autonomous vehicles, social robots, virtual assistant etc. (Vermeulen et al., 2018). These technologies are significant and broad-based on their scope and have the ability to help people in their daily routine tasks (West, 2015). These new technologies belong to a particular group of families called General Purpose Technologies (GPTs). Compared to previous GPTs (ICT) these new technologies are quicker in their diffusion and adoption (Barbieri et al., 2019). As already mentioned in the previous paragraph, this advancement in innovation has been a long term debate on how these signs of progress are beneficial to mankind. On the one hand, it is making human life easier, on the other hand, it is taking away most of the skilled jobs done by humans. The quality and quantity of demand for jobs and skills related to the new labor market have changed considerably. 20th century has been a debatable era among most researchers on technology directly affecting the labor. Evidence shows that in spite of occupational shift and sectorial change, the aggregate labor rate kept on increasing (Nedelkoska & Quintini, 2018).

There is a prediction that one-third of current jobs can be performed by machines or intelligent systems that require a minimum bachelor's degree. An autonomous system can perform without being tired and can perform 24/7 and reliably which is more accurate and efficient than humans (Wisskirchen et al., 2017). Autor (2015) claims that substitution and complementary effects are one of the factors which augment the impact on automation on labor. He argues that the workers are benefited by automation if the task is complemented; however, it is not beneficial to the workers if the tasks are substituted by automation (Autor, 2015). Various authors came up with a hypothesis that was related to the complementary effect of automation on employment. One such evidence was provided by Autor where he used the skilled biased technological change as reference. Here he claims that computer biased routine tasks changed the labor demand during 1960-80 in the USA. Computer driven tasks were used for routine tasks whereas the non-routine tasks were complemented by humans. However the concern about the automation and artificial intelligence displacement on employment is on increase regardless of the empirical evidence which are found by researchers (Martens & Tolan, 2018).

3.4.1 Skills and jobs change due to AI and automation

Adoption of technologies like automation and artificial intelligence will increase the benefit in the form of economic growth and enhanced corporate performance (Bughin et al., 2018). Along with these benefits at the workplace, as stated previously there will be a risk to

some of the jobs and skills. Prediction of future job growth is a tedious process. Predicting the estimation of jobs at risk due to technology that is yet to be established is extremely difficult (The White House, 2016). Martens & Tolan (2018) argues that the authors who have predicted the jobs that are at risk of AI have gone past the empirical evidence and beyond the task-based approach. Marten and Tolan claim that they have not considered the complementary effect on employment and wage effect. One of such evidence was found in the paper by (Frey & Osborne, 2017). Where the author has taken just the negative effect of the automation and has not considered any positive effect such as complementary employment or wage effect.

On the other hand as already mentioned in section 3.3 the change in technological innovation all leads to enhancement and requirement of new skills. The availability of multidisciplinary alternatives due to AI, requirements of the future employees also changes. (Wisskirchen et al., 2017). Bughin et al., (2018) predicts that there will be a high demand for IT and programming skills in the coming future. As most of the sector will be adopting AI and automation as its core technology. Advanced data analyst and mathematics, engineering and maintenance, scientific research and development and engineering design are expected to increase but not to the extent of IT and programming skills (The White House, 2016; Wisskirchen et al., 2017). Apart from the above said technical skills, there will be demand and requirements of a certain category. They are categorized into physical and manual skills, social and emotional skills, basic cognitive skills and higher cognitive skills. By the adaption of advanced technologies like AI and automation, it is predicted that there will be increase in demand in emotional and social skills by 26% in USA and 22% in Europe alone. However the demand for higher cognitive skills decline gradually and it is predicted to increase only 19% in USA and 14% in Europe. Similarly, physical and manual skill will also face a decline in growth in the coming future. These skill shifts is not similar in each countries as it differs depending on the digitization level, economic structure and sector mix (Bughin et al., 2018).

From the above paragraph, it can be concluded that there will be a complementary employment effect between the automated tasks and humans. Tasks are combined with human involvement to reproduce the underlying production process or complete that particular task. For example, a facial expression algorithm can note down a complaint or an issue, but there is a requirement of involving a human who has the knowledge about the subject and be eligible to resolve the issue. Similarly, the job handled by an office clerk can be easily automated, but there is also a need for creative, physical manipulation skills or social skills to finish the particular task. Council of Economic Advisors (CEA) segregated future AI-driven growth into four categories where the AI will be having a direct impact on the labor market (The White House, 2016).

- *Engagement*: Human interference is much needed when the process is driven by AI technology. In the field of medicines, AI-driven technology can detect the early presence of the cancer cells in the patient. But there is a requirement of human engagement to talk with the patient and guide them through the recovery process.

- *Development*: The initial development of AI is highly dependent on highly skilled software developers and engineers. It is completely dependent on data available; hence there will be demand for an occupation such as collecting, managing and generating relevant data.
- *Supervision*: Tasks such as repair, monitoring and licensing of AI technology will be a great demand in the future. Tasks such as testing, monitoring, repairing and maintenance of AVs have a prominent increase in the future. This leads to expand of technician and mechanic jobs.
- *Response to paradigm shifts*: Reshaping of the environment around AVs will be having an increase in demand. For example, the introduction of AVs will be in need of a new design of infrastructure, so there will be an increase in the requirement of urban planners and designers.

Technological progress such as AI and automation has an ambiguous effect on the employment of society. These signs of progress have been considered as the fourth industrial revolution. However, these technologies will take a long period to have a significant impact on society. On a general note, technological progress has led to lowering the demand for the old product and hence reducing the demand for employment. But on the contrary, the new product that has been developed increases the demand for people to work on the new technology and make it successful. Various compensation mechanisms can counterbalance the reduction in labor demand as stated in the above paragraph. According to technology optimists, each wave of technological change in the past has generated technological anxiety and has led to temporary disruptions leading to the diminishing of certain jobs and tasks, but other jobs were modified and better jobs were eventually developed and filled. However, technology pessimist argues that past technological unemployment has been proven wrong many times. Definitive conclusions on the exact outcome of the new wave of technological innovation on labor markets, however, remain elusive for the present.

3.5 Sectors to be affected due to the introduction of AVs

A study from Deloitte University Press stated that there are few driving forces to create a new ecosystem for transport and mobility ranging from mature power train technologies to automation (Després et al., 2018). Companies such as Apple, Google and Uber are constantly working on the research and development of AVs. AVs may set a revolution in the transportation sector across the globe. This requires market penetration or significant adoption by the public. But, this will create an impact across the industries and markets across the globe (Clements & Kockelman, 2017). Below are the few listed industrial sectors that might be affected by the AVs from the literature. Research is also done by gathering on-ground knowledge via interviewing the academicians who will be discussed in Chapter 4 – Discussion and analysis

Automotive industry: Automation and connectivity have a significant effect on the automotive industry as there will be a change along the value chain. Due to the emergence of new mobility

behaviors, there will be an effect on demand for new mobility requirements and new vehicles (Després et al., 2018). Römer et al (2016) claim that presently there are 90% of the values is due to hardware in the value of the car while the other 10% is due to the software. But in the future, there is a possibility in a change of share where the manufacturers increase the value of the share for software up to 40% to increase their profit (Jonas et al. 2014). Apart from affecting the manufacturing process in an organization, the introduction of autonomous vehicles will also influence the automotive landscape such as Mobility-as-a-service (MAAS). This will open up mobility for certain people like disabled, old aged people or even young people who are yet to get a license. But, this facility will have a negative effect on vehicle ownership and thus decrease in the number of sales (Després et al., 2018; Fagnant & Kockelman, 2015). As the share shifts towards more to the software side, the required skills shift to more into software development rather than vehicle structural development. Along with this there are requirements of knowledge and skills in understanding and communicating specific knowledge about the vehicles to the customer in wholesale and retail departments (Després et al., 2018).

Electronics and software industry: As stated above, software being the highest concern and holding 40% of the vehicle value, technology firms will be having the most gain of it. Technology firms will be playing a major role in the manufacturing process, as the base of technology is dependent on artificial intelligence (Jonas et al. 2014). Along with the software, hardware components such as lidar, cameras, actuators, sensors and communication systems for autonomous vehicles will also grow. As mentioned AVs are more dependent on software, the requirement of ICT skills also increases. Currently, in the EU, firms are struggling to fill in the vacancy for IT jobs as there is a lack of qualified personnel who can handle the complex informatics system for navigation for AVs (Després et al., 2018).

Freight transport industry: It is predicted that the freight transport sector might experience the most adverse effect on employment after the introduction of AVs as the majority of the employees are drivers. It is predicted that after the introduction of truck platooning, only the leading truck will be in need of a driver and rest can be without a driver. But attendants will still be in use for monitoring administrative tasks, helping in dropping and pick up stations (Clements & Kockelman, 2017). On the other hand, the transport companies will be benefited by truck platooning. By using the new transport system, transport companies can increase their productivity by the same number of drivers and transporting more loads than before. Single drivers can take 5 trucks in the truck platooning and increasing productivity per day. Along with the increase in productivity, this new system can improve fuel efficiency, congestion and safety features (Després et al., 2018).

Passenger transport industry: This is a combination of passenger rail transport, taxi sector, passenger air transport and car rental/leasing (Clements & Kockelman, 2017). As the vehicle will be in control by computer, the commuters can be more productive, thus giving more time during car trips and decreasing demand for fast travel to the destination (Diamandis, 2014). For example, if the destination is 8+ hours of journey, the commuter need not take the fast travel

option. Instead, an individual or group can travel by AVs. Thus it might lead to a loss for buses, airlines, trains and car rental companies. The biggest change in personal transportation as a result of the development of AVs might be in the mode of transportation for short commutes. With CAV technology, companies could develop an "on-demand" taxi service with AVs that would make human-driven taxis obsolete (Clements & Kockelman, 2017; Després et al., 2018).

Insurance: Safety is one of the major benefits of AVs. This obliges insurance agencies to reconstruct their strategy and underwriting models. Currently, the main stakeholders for the insurance companies are the individual vehicle owners and human drivers who are liable for car crashes. The current net worth of insurance agencies providing insurance against accidents caused by automobiles and the related medical cost is $180 billion annually in the U.S (Clements & Kockelman, 2017). When driving becomes the job of computers, deciding if the driver is solely responsible for the crash would be ambiguous. This makes automakers and the vehicle's software developers to be the main responsible parties. These factors oblige the automakers and software developers to purchase insurance for the technical failure of the automobiles and making personal policies more limited in scope (Silberg & Wallace, 2012). However, the owner of the vehicle will be held responsible if the vehicle is driven in certain out of scope such as during wet, icy or unsafe conditions.

3.5.1 The estimated effect on skills and job types by AVs

Estimation of the number of jobs at risk and emerging due to the introduction of AVs is difficult to pinpoint in numbers. Frey & Osborne (2017) estimates that 47% of jobs will be at risk due to automation alone USA, whereas OECD (2018) estimates only 9% of jobs are at risk. Currently, AVs are not in the position to perform most of the required driving-related jobs (Litman, 2018). Along with that, AV technologies such as adaptive cruise control, blind-spot warning lights, hand-free calling with touch screen interface and others control need a driver with a particular skill set to drive safely in the traffic (Spulber & Wallace, 2016). This creates jobs for high skilled labor but eventually, low skilled laborers lose their jobs. United States researchers like Beede, Powers, and Ingram concluded that out of nine, one person's work will be in jeopardy because of the introduction of AVs (Beede et al., 2017). Many consulting companies like ATKINS and KPMG are constantly working on future estimations of the benefits of the introduction of AVs. ATKINS also estimates that AVs might create around 320 thousand additional jobs in the UK alone by 2030, but there is insufficient data to prove this claim (Cavoli et al., 2017). According to Cutean (2017), new occupations such as automated driver system engineers, AV trainers are starting to emerge in Canada. Based on the federal budget allocation in Australia, it is predicted that there is a possibility of the creation of 932 direct jobs and 1059 indirect full-time jobs related to AVs (Haratsis et al., 2018). Also according to European Economic Social Committee, it is expected there might be a decrease in physical and routine tasks but however, there will be an increase in problem-solving, creative tasks and more (Després et al., 2018). Due to this advancement in technical skills, there might be reduction in physical and routine tasks. But, creative tasks, problem-solving skills will be an increase in demand.

3.5.1.1 AV-Related manufacturing

The technology and components behind the manufacturing of AVs are immense. It has to be integrated with both hardware and software components. According to (Després et al., 2018) there will be a huge demand for automotive sector skills. European Automotive Skills Council (EASC) ranks automotive sector skills to fourth position after advanced skill set in manufacturing, material knowledge and knowing customer preferences. Accordingly, there will be an increase in technical requirements skills and there will also be a sectorial shift in skill s mainly to software development (Dachs and Zanker, 2015). The employment effects on skills for the electronic and software industry is predicted to be positive. There has already been a high dependency on the land transport sector on ICT-based equipment and the skills required to operate them. Along with the ICT skills, there will be an increase in the requirement of expertise in data management to handle the complexity between the data collected by various infrastructure and different devices. These changing workforce environments, demands required skills to evolve significantly and also increase the level of education (Hawksworth et al., 2018). A list of some of the job types and corresponding required skills that could be emerging was formed by (Cutean, 2017) which can be seen tabulated in ***Table 6***.

Table 6: AVs occupation and corresponding skill requirements Source: (Cutean, 2017)

Sl No.	Job titles	Skill requirement
1	Autonomous systems machine learning specialists	Widespread programming background (Java, Python, JavaScript, etc.)
2	Automated driving engineer	Cloud services development
3	Software engineer robotics	Java spring framework
4	Vehicle lab manager	Messaging protocols (DDS, MQTT, AMQP), experience in testing android
5	Automated driving research engineer – embedded software	Experience with test automation framework, tool development
6	Autonomous vehicle platform system engineer	Knowledge of scrum/agile software development process
7	Operation specialist – Autonomous driving test	Experience with vehicle communication network protocols (CAN, MOST, etc)
8	Test driver ADAS mechanical engineer	Experience testing interactivity of desktop
9	Fusion algorithm development engineer and Hardware development engineer – Robotics	Automation toll and scripting experience for both front end APIs
10	Vehicle application engineer	Embedded C programming, Matlab/Simulink
11	Autopilot software engineer research scientist	General knowledge of automotive systems (Powertrain/Brakes)
12	Transportation engineer	Experience with vehicle dynamics modeling and CarSim
13	Autonomous driving algorithms, AI and deep learning	Advanced statistical analysis, signal processing, filter design optimization, system identification
14	Diagnostic repair technician	Experience with test and validation, design and development of a solution for wireless power

3.5.1.2 AV- Related services

As mentioned earlier the main service sectors affected due to the introduction of AVs are the drivers in the freight and passenger transport sector. In the EU, drivers and mobile operators account for 42.4% of workers in the land transport sector. This not only accommodates drivers from taxi and freight. But also sectors like warehousing and support, construction and retail trades (Després et al., 2018). Reskilling will be helpful for the freight drivers to get accommodated with the new types of technology. Abilities and responsibilities like managing and operationalizing the fleet will be a great increase among the fleet owners. Hence they should be having knowledge on how to operate tracking systems, dynamic routing of AVs and more. A recent study by CEDEFOP concluded that the drivers and mobile plant operators have five main skills and they are, problem-solving, communication, teamwork, job-specific skills and learning. Apart from automotive sectors, there will be a huge impact on skill demand at wholesale and retail distribution. There will be an increase in skilled workers who have more communication with customers regarding knowledge related to AVs technology (Dachs and Zanker, 2015). Depending on the average size of the companies, level of education and adoption rate of a country and a firm, there will be an effect on maintenance and repair firms.

3.6 Conceptual model

So far we have discussed how technological innovation has its effect on employment and how the imbalances in skill have led to different skill mismatch. It can be seen that there has been a requirement of skills or imbalance in skill whenever there is a change in technology in society. The development of AVs can also be related to technological progress. It can be argued that AVs also undergo similar changes as the rest of the technological advancement which has occurred in history from the evidence found in the literature on sectors that might get affected. The below paragraph gives a descriptive explanation of the conceptual model. The variables related to each other are shown by arrows and letters in the figure. The alphabets along the path of dependency of the variables are used to explain the model descriptively in the next paragraph

The components and dynamics of skill mismatch mentioned in the report by (European Commission, 2012) give an outline of how the new technology like AVs will have its effect on employment based on the terms of skills and job types. Earlier in section 3.3.1, we discussed the history of how technology and employment are interrelated, the introduction of AVs also leads to an increase in labor productivity. From the components of skill mismatch and the framework by Est & Kool (2015), it can be seen that technology leads to an increase in labor productivity shown by path ***(A)***. To unlock the full potential of the new technology like AVs, it is required to have new skills to work on it. After the introduction of AVs, it is predicted that there will be a certain effect on the industrial and service sector which can be inferred from section 3.5.1. To get familiarized and adopted with the technology there will be in demand for skills that can be shown from the path ***(B)***. Accordingly, if there is a demand for skills there should always be a supply of skill to compensate for the losses. From section 3.5.1 it can be concluded

that their firms are have already forecasted the number of jobs that might be affected and thus leading to the requirement of specific skill supply to meet the demand due to the change in technology and this can be seen by path ***(C).*** Due to adjustment lag between the education provided by the institutions and the training system, lack of occupational and geographical mobility may lead to a shortage in skill supply. This difference between the skill supply and skill demand leads to skill mismatch. As mentioned in section 3.3.2 this creates an imbalance in the skill set for the employers or the firm. This imbalance can be seen in the model by the path ***(D).*** Also due to the skill mismatch, there will be a change in the labor productivity and forms a loop in the model which is inferred from the components and dynamics explained in section 3.3.2.1 and can be seen by the path ***(G)***. There are five types of skill mismatch namely, skill shortage, skill gaps, over education or under education and overqualification or under qualification, which is explained in the previous section 3.3.2.1. These various types of skill mismatches can be found in many workforce sectors. It is assumed that it is not necessary that all the workforce sectors should have the same set of skill mismatch. The automotive industry, electronic and software industry might be in need of higher types of skill. By the definition and discussion made in section 3.3.2.1 about the type of skill mismatch, it can be argued that these two sectors will undergo various types of skill mismatches. There is no conclusive literature on the type of skill mismatch the sectors might undergo after the introduction of AVs. As one of the objectives of the research is to find how the skill mismatch affects employment due to AVs, the second part of the methodology i.e. interview by academicians and experts is used to conclude the dependencies of these variables.

The above-mentioned types of skill mismatch experienced by the labor workforce industry are time factor-dependent. There is evidence from history and also in section 3.3 discusses that all technological advancement has initially led to unemployment due to the difference in the skill set and task performed. As the demand for skill increases there will always be a supply of skilled laborers to create balance in the economic world. It is also predicted by various experts that the AVs will also undergo similar changes just like the other technology and this can be seen by path ***(E)*** and ***(F)***. Now that we have found out variables that affect the AVs' employment based on the skills and task types, it can be represented in the pictorial representation which can be seen in ***Figure 7***.

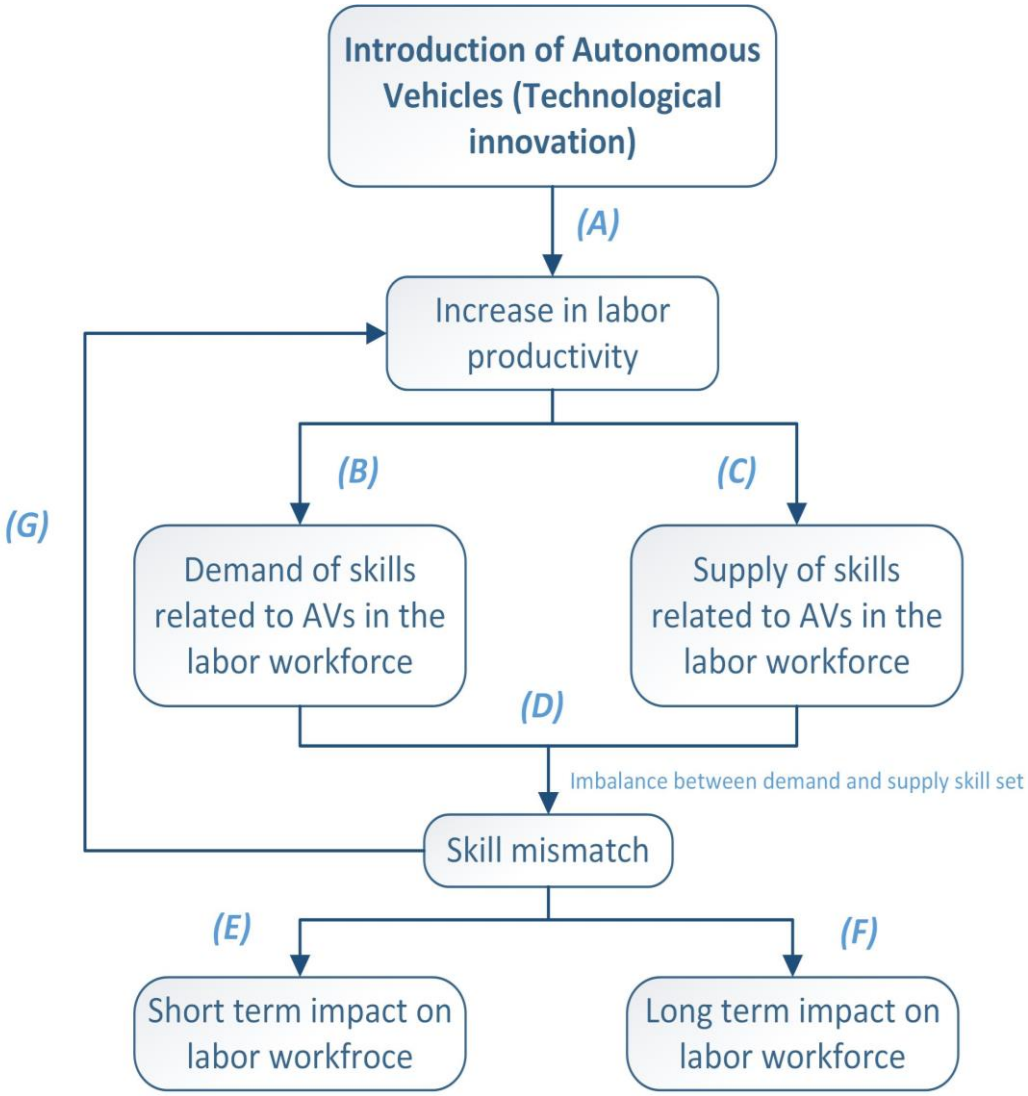

Figure 11: Conceptual model of the relation between AVs, labor market and skill mismatch

Chapter 4: Interview results

So far in the previous chapter, we have discussed the fundamentals of the relationship between employment, technology, and skills. As we already know one of the objectives of this research is to find out how skill mismatch affects the employment condition in The Netherlands after the introduction of level 5 of AVs. The interview was conducted based on this objective and to answer this sub research question. This chapter gives the result and interpretation of the entire 13 semi-structured interviews: 12 interviews were conducted with academicians from universities and 1 interview with an economic expert from the labor market. There are two parts of the interview, the first part is comparing the respondents rating given to the proposals. The second part is interpreting the result with the help of themes, categories, and coding.

4.1 Analysis of data from Part A of the interview

As explained in section 2.2, the interview with the academician and the expert was divided into two parts. In the first part, the respondents were asked to rate the scale on how the skill mismatch and introduction of AVs are related to each other. Seven questions were asked to each interviewee and asked them to rate the questions based on the three-pointer scale. ***1 - Agree, 2 – Neutral, 3 - Disagree***. Below sections show the respondent's response for each of the seven questions and the result for each of the proposals. The conclusion derived from each of the proposals is then taken and combined with the conclusion derived from the descriptive interview question and answers of ***Part B.***

Table 7: Rating percentage by academicians

Sl No.	Questions	Ratings		
		Agree (1)	Neutral (2)	Disagree(3)
1	After the introduction of the highest levels of AVs, skill mismatch is one of the main factors which affect employment in the labor workforce	**30.7%**	**30.7%**	**38.6%**
2	Skill mismatch will be a barrier between the employers and employees after the introduction of AVs of the highest level of automation	**30.7%**	**30.7%**	**38.6%**
3	Skill mismatch will be a huge concern in The Netherlands after the introduction of AVs	**7.7%**	**7.7%**	**84.6%**
4	After AV adoption, skill mismatch in the labor workforce is a short term period problem	**61.5%**	**23.1%**	**15.4%**
5	After AV adoption, skill mismatch in the labor workforce is NOT a long term period problem	**77%**	**15.3%**	**7.7%**
6	The effect of skill mismatch on labor workforce is similar to each level (0 to 5) of automation of AVs	**7.7%**	**15.3%**	**77%**
7	There will be resistance from workers in the traditionally low skilled industry after the introduction of AVs	**77%**	**15.3%**	**7.7%**

Table 7 shows the percentage of ratings of each of the proposals asked academicians and the expert. For example, there were mixed opinions between each academician. Some of the academicians from the T&P department agreed to one of the proposals whereas the others had a disagreement and neutral opinions. This is shown coming paragraphs. Descriptive statistics (mean, median, mode, standard deviation, and skewness) values were tabulated for each of the proposals. This can be seen in ***Appendix I***. In this section, the reader will be getting a helicopter view of Table 7 and then in section 4.2, the reasoning for the rating is stated along with the quotes given by the respondents.

The first proposal stated that ***"After the introduction of highest levels of AVs, skill mismatch is one of the main factors which affect the employment in the labor workforce in The Netherlands"***. Here we can see that there is a mixed opinion between the academicians and the expert. It was seen that out of 13 respondents firstly, 4 academicians agreed among which 2 were from E&I department and 2 academicians from the T&P department. Secondly, 4 academicians had a neutral opinion among which 2 were from the AI department and 2 were from the T&P department. And lastly, 5 people disagreed with the proposal among which 4 were from the T&P department and 1 expert from the labor organization. Here we can see mixed opinions among the academicians of the T&P department. Overall there was a balanced opinion for this statement.

The second proposal stated that ***"Skill mismatch will be a barrier between the employers and employees after the introduction of AVs of the highest level of automation in The Netherlands".*** This statement also had mixed opinions between the academicians and the expert. It was seen that out of 13 respondents firstly, 4 academicians agreed among which 2 were from E&I department and 2 academicians from the T&P department. Secondly, 4 academicians had a neutral opinion among which 2 were from the AI department and 2 were from the T&P department. And lastly, 5 academicians disagreed with the proposal among which 4 were from the T&P department and 1 expert from the labor organization. Here we can see mixed opinions among the academicians of the T&P department. Overall there was a balanced opinion for this statement

The third proposal stated that ***"Skill mismatch will be a huge concern in The Netherlands after the introduction of AVs".*** Here from the table, it can be seen that there is a maximum of disagreement for the statement among the academicians and the expert. It was seen that out of 13 respondents, only 1 person from the T&P department agreed to this statement. Also, there was 1 person from the T&P department had a neutral opinion. And lastly, the rest of the academicians and the expert from the labor organization disagreed with the proposal that skill mismatch problem will not be a huge concern in The Netherlands.

The fourth proposal stated that "***After AV adoption, skill mismatch in the labor workforce is a short term period problem"***. This statement had a maximum agreement with the statement among the academicians and the expert. It was seen that out of 13 respondents, 8 people agreed to the statement out of which both academicians from the E&I department,

the expert from a labor organization, both the academician from the A&I department and 4 people from T&P department agreed for the statement. However, 2 people from the T&P department had a neutral opinion. But, only one academician from the T&P department disagreed with the proposal that the skill mismatch problem will not be a short term problem.

The fifth proposal stated that "***After AV adoption, skill mismatch in the labor workforce is not a long term period problem"***. This statement too had maximum numbers of agreement. It was seen that out of 13 respondents. Only 1 academician from the T&P department disagreed with the proposal. However, 2 academicians from the T&P department had a neutral opinion. But, the maximum number of academicians from all the three departments agreed that the skill mismatch will not be a long term problem.

The sixth proposal stated that ***"The effect of skill mismatch on labor workforce is similar to each level (0 to 5) of automation of AVs".*** This statement has maximum disagreement by academician and the expert. However, only 1 academician from E&I department agreed that the effect of skill mismatch is similar at each level of automation of AVs. Along with it, 1 academician from E&I and the AI department had a neutral opinion. But the rest of the academicians from the T&P department and an expert from the labor organization disagreed that it will be changing for each level of automation of AVs.

The final proposal stated that ***"There will be resistance from workers in the traditionally low skilled industry after the introduction of AVs"***. From the table, it can be inferred that there is a maximum of the agreement for the statement among the academicians and the expert. It was seen that out of 13 respondents, only 1 person from the T&P department disagreed with this statement. Also, there were 2 academicians from the T&P department who had a neutral opinion. And lastly, the rest of the academicians and the expert from the labor organization agreed with the proposal that there will be resistance from the workers in the traditionally low skilled industry after the introduction of AVs.

It can be concluded that skill mismatch might be a major factor that affects the labor market after the introduction of AVs according to some of the academicians. But some had the opposite opinion. Also, the skill mismatch will not be a major concern in the Netherlands after the introduction of AVs. From the ratings, it can also be seen that the skill mismatch effect on employment due to the introduction of AVs is a short term problem and it is not a long term problem. From the rating table, it was difficult to conclude if the skill mismatch will be a barrier between the employer and the employees. It depends on at which rate the AVs are introduced to society. The skill mismatch will not be having its major effect on labor workforce on each level of automation. But on the other hand for low skilled workers, it will be a hurdle or chaotic situation to find new jobs and they offer resistance in the wide adoption of AVs in society. The detailed explanation and reasoning of the above proposals and further discussion are carried in the next section.

4.2 Analysis of data from Part B of the interview

This section gives the reasoning behind the ratings given for the proposals' of **Part A.** The respondents were asked questions based on the theoretical framework, literature referred and connected to the proposals stated in Part A. A total of 11 questions was asked to each of the academicians and the expert. The interview questions and the reason behind asking, are explained previously in section 2.2.3.

4.2.1 Decisive list of codes and categories

In the process of coding, two phases were carried out as explained in section 2.2.4. A total of 83 codes were generated. In the list of these 83 codes, as explained in section 2.2.4 upon the formation of abstract codes, there are 12 abstract codes and 6 categories. A maximum number of codes were generated in the first four interviews. The later stage of the interviews gave a very little number of new codes and no new codes were generated. However, the later interview helped in developing a more in-depth understanding of the codes. Further coding iteration was done to get a definitive codebook. This gives an overview of the code categories and the number of codes in each category. It also helps us to understand the frequency of particular codes that were used in each interview. ***Table 8*** gives an overview of the list of categories and a number of codes. The main categories which are used to extrapolate the results are *skill mismatch effects, skill mismatch duration, the introduction of AVs, government and employer's involvement, winners and losers of AVs and resistance from laborers.*

Table 8: Code categories and number codes in each category

Code category	Number of codes
Introduction of AVs (IAV)	19
Skill mismatch effects (SME)	21
Skill mismatch duration (SMD)	2
Government and employers involvement (IGE)	22
Winners and losers of AVs (WLA)	12
Resistance from labors (RL)	7
Total	**83**

There is a total of 83 codes generated by the interview transcript and literature. Each code referred to opinions and attitudes with respect to the interviewee's point of view. ***Table 9*** shows us the top 22 most common code used by the respondents and the frequency of usage and groundedness. Codes with groundedness higher than 10 are listed below. Based on the highest number of interview quotations assigned to each code, the list has been tabulated in decreasing order. This indicates that the codes on the top of the list were mentioned in higher frequency by the interviewees. Apart from the preliminary list of codes from the literature, we got additional codes from the interviews.

Table 9: *Common code used by respondents*

Sl No.	Code	Part of category	# Grounded
1	*Skill shortage*	*SME*	*30*
2	*Skill obsolescence*	*SME*	*30*
3	*Retraining*	*IGE*	*30*
4	*Unemployment*	*IAV*	*27*
5	*Skill gap*	*SME*	*25*
6	*Minimal issue*	*IAV*	*23*
7	*Educate labors*	*IGE*	*22*
8	*Over education*	*SME*	*20*
9	*Over qualification*	*SME*	*20*
10	*Creation of new tasks*	*IGE*	*19*
11	*Freight and transport industry*	*WLA*	*19*
12	*Creation of new tasks*	*IGE*	*19*
13	*Changes in educational system*	*IGE*	*18*
14	*Low skilled job*	*RL*	*15*
15	*Under education*	*SME*	*15*
16	*Under qualification*	*SME*	*15*
17	*Low educational level*	*RL*	*14*
18	*Short term duration*	*SMD*	*13*
19	*Job replacement*	*IAV*	*12*
20	*Skill supply*	*SME*	*10*
21	*Cognitive skills*	*SME*	*10*
22	*Skill demand*	*SME*	*10*

In general academicians and the expert were interested in sharing their views and expertise on how the introduction of AVs would affect the labor market in The Netherlands related to skills and job types. The common answer by the interviewee was that there will not be much of the skill mismatch problem in The Netherlands. Compare to other countries the skill mismatch problem will be very minimal here in the Netherlands. Currently, the unemployment rate is also very low and there are a large amount of high skilled laborers. Many interviewees expressed that "if the AVs are introduced in the incremental process, there will not be a skill mismatch problem". Results also showcased the factors causing skill mismatch, types of skill mismatch, labor workforces being affected by AVs if there will be resistance by low skilled laborers and preventive measures by government and employers to minimize skill mismatch. Interviewees were main concerned about the people who had physical and manual tasks as they will be losing their jobs in higher rate compared to technical skills. Considering freight industry as an example skills such as social and emotional skills will be having a huge demand as the AVs introduction will making more monotonous routine for the passenger. And hence interviewees acknowledged that there will be need of social and emotional as one of the main skills in a driver. A total of 83 codes were identified after two iterations. These codes are categorized into the code categories as mentioned in **Table 8.** The complete list of codes in respective code categories can be found in **Appendix II.**

Interpreting the table above, the following top codes are found most important codes in each code categories by each interviewee.

- **Introduction of AVs**
  Incremental process – Gradual manner of introduction of each level of AVs
  Unemployment – Employees will unemployed due to lack of skills
- **Skill mismatch duration**
  Short term – It might be a five-year problem, but it all depends on how soon the AVs are introduced
- **Government and employers involvement**
  Retraining – Training drivers with new skills to motivate them to indulge with a new type of jobs
  Creation of new tasks – Emergence of a new type of jobs for unemployed labors
- **Resistance from labors**
  Low skilled job – Low skilled employees will be losing jobs as the jobs will be getting obsolete
  Policy protection – Government helping the low skilled labors
- **Winner and losers of AVs**
  Freight industry – Most affected labor workforce, as there will be a loss of drivers
  Electronics and software – Increase in the number of labors and occupation in the labor workforce

4.2.2 Allusive representation of interview results

This section explains more closely the type of code categories and codes generated from the interview transcript. A list of code categories and top-order codes are listed in the table in the previous section. An allusive representation of result means that result is supported by the citation and quotations derived from the interview with the academicians and experts. The complete detailed report of the interview can be found in ***Appendix 1.*** First the code categories and codes under ***Theme 1 – "Planning for unavoidable"*** are analyzed and discussed. Later code categories and codes under ***Theme 2 – "Change in occupation and industry"*** are analyzed and discussed.

4.2.2.1 Introduction of AVs

This code category was formed by combining code categories related to initial changes in the labor market after the introduction of AVs. The code categories can be classified as *adaptability of AVs* and *changes in the labor market*.

Adaptability of AVs

The adaptability of AVs had different aspects like the introduction of AVs being an incremental process, gradual introduction of AVs and introduction of AVs being a skeptical scenario. When the interviewees were asked if the AVs would be affecting employment in the labor market, they all had mixed opinions and it was hard for them to predict the scenario which is not yet been established worldwide and adopted by the whole population in the world. All the interviewees were commonly giving an opinion on the technology of AVs being introduced to the market that is not happening very soon or might not also happen. They were very skeptical about the introduction of the highest level of automation being introduced to the market.

> **Q1.** *ICB: "Let me say that I am very skeptical that the highest AV level will be here anytime soon". Also, ICH tells its hypothetical situation, interviewee gave a response that "I think we're talking about a situation of autonomous cars of level five, that might not occur for the next decades if ever"*

When interviewees were asked, considering the hypothetical scenario on the introduction of AVs and how that situation would affect the employment and maximum of the response was that if the AVs are introduced gradually or introduced at an incremental level as in level 2 to level 3 and then to level to 4 and then to level 5. To extent of expecting positive outcomes could be by strategic initiatives designed to minimize the disruptive outcomes. Society will be accepting the AVs and accordingly, we can see the changes in employment when the transition happens from level 2 to level 3 itself. This will help in minimum damage in the labor market when the highest level of automation (level 5) is introduced to society.

> **Q2.** *ICD: The interviewee believes that if the introduction of AVs is gradual the society will be able to adapt to the situation and there won't be much effect on employment. He says "I think that skill mismatch (employment affect) is not the*

biggest concern as AVs will be introduced gradually (perhaps multiple decades) so workers will be able to adjust to gradual changes."

Another interviewee responded that we should not just introduce the society directly to the highest level of AV. It should be incremental so that the system can train their employees and thus reducing unemployment and minimizing the skill mismatch among the employers and employees.

Q3. *ICG: "It's not that you first introduce a piece and then consider the skill match. It happens at the same time. It's an incremental process. So you would never introduce public transport systems without training drivers. So we're not saying we're first going to introduce buses and then after the introduction of the buses, we're going to see if we have drivers."*

Changes in the labor market

The interviewee was asked hypothetically if the AVs was introduced to the society how will it be affecting the labor market and the response from all the interviewees was that there will downgrade of employment if the country is not taking precautionary measures beforehand. They also responded that it depended on how the country is developed in the technology and educational system. It will be causing changes in the labor market by causing some of the occupations and skills less obsolete. Among the other countries, the Netherlands is one of the top countries having high skilled labors. The interviewee was asked if the Netherlands would be having a skill mismatch and will it be the main factor affecting the labor market. From the rating of the proposal from Part A and the elaborate description given by the respondent gave us a conclusion that it might not be the main factor but definitely the factor that would cause changes in the labor market. The level of wages, state of aggregate demand and extend of public expenditure are some of the factors that affect the labor market along with the skill mismatch after the introduction of AVs Also one of the respondents told that it also depends on other "best practices", how the countries motivate themselves on improving their technology and adapt to the same.

Q4. *ICC: "So considering the case in The Netherlands, it is quite prepared for things like that, the labor force on an average is a bit higher skilled and the industries are more of high end. In Netherlands on an average the people are educated, more skilled. Definitely, these things will be impacting the skill mismatch. Netherlands position itself in the top five."*

Q5. *ICF: "There will be differences between countries, due to the different "digital-affinities" of the different countries. I can mainly compare Germany and the Netherlands and would say that the Netherlands are more likely to adopt new technologies quicker, due to the overall mentality."*

> **Q6.** *ICB: "I don't think it would be a major factor, and other things like the state of aggregate demand, the level of wages and the extent of public expenditure whether it is expansionary or contraction."*

Maximum of the respondents considered that the skill mismatch problem is not a big issue in the Netherlands; it will be a very minimal issue that affects employment after the introduction of AVs. But the expert (interview code C) believes that skill mismatch will be one of the main factors that affect the labor market. He tells that in the traditional economic model there are two factors of production i.e. labor and capital. The respondent took the reference from the paper by Acemoglu and Autor and responded that there is always a window for the creation of new tasks thus having tasks for laborers. Along with the creation of new tasks, there are possibilities that the skills required for the tasks are low and there is bias in skill leading to skill-biased technical change. Countries with a workforce

> **Q7.** *ICC: "There are two behaviors here. The one is to what extent the automation going to lead to the creation of these new tasks. It might not even create new tasks for labor. Let's make it specific to AVs, you have self-driving vehicles, all companies fire everybody because they went for automation, and they just saved money like this. But you could also think that maybe they do not want to fire everyone. And, of course, this relates to the context of every country. So in the Netherlands, it would not be easy because of the situational settings we have."*

Also, the same interviewee mentioned that after the creation of new tasks, the employers will be in an urge to make their service better with the existing types of skilled worked thus increasing labor productivity.

> **Q8**. *ICC: "And then maybe companies think that they actually want to create a new task for this labor. I want to improve my service. And I'll have like a host in every bus that welcomes people, so you just add human interaction, but the bus is being driven by itself."*

A maximum number of interviewees responded that there will be a rise in unemployment in some of the sectors due to the skill mismatch factor. As the existing skills will be vanishing and the respective labor will be without jobs. The laborers will be getting jobs only if they have any other skills related to the new technology or should be updating their skills related to the AV technology. And as the level of automation increases, the workforce will be more expensive and the skill mismatch factor rises and hence decreasing the employment rate.

> **Q9**. *ICB: "The extent that skill mismatches are a reason for unemployment, or low employment leverage, presumably at the higher automation level the problem will get more severe."*

> **Q10.** *ICH*: "*I think there will be a different set of skill mismatches compared to highest automated countries probably will. The more expensive your workforce is, the more interesting is the job more to be automated and the least expensive or less or the biggest problem will be there in the countries that will have a lower paid wage force"*

When the interviewees were asked about the inequalities in labor market after introduction of AVs, they responded that once there is rise of high skilled worked in the labor workforce; there will be major danger in consolidating economic inequality trend in The Netherlands. The economic return of high skilled workers will be greater than the lower skilled workers as the former side will be generating more added values to the society.

> **Q11.** *ICD: "What could be a concern is growing inequality in society, where, in the long term, jobs will become more, and more tech (programming procedures) and less manual control. A large part of society may not be able to get such jobs."*

4.2.2.2 Skill mismatch affects

This code category was formed by combining codes related to skill mismatch affects after introduction of AVs. The abstracted code can be segregated as, *Imbalance between skills sets, skill mismatch types, skill mismatch, reduction of skill mismatch and skill categories.*

Imbalance between skills

Once the new technology is introduced to the society there will be need of skills and supply of skills accordingly. Skill mismatch is the result of imbalance between the skill supply and skill demand. Interviewees were more concerned about the skill demand and skill supply once the AVs are gradually introduced to the society. Most of the interviewees acknowledged that there will be demand for more of labors who are expertise in programming and data science. ICH recognized that there will be demand for truck or bus drivers who can monitor the vehicle and help the passengers on board to reach their destination safely.

> **Q12.** *ICJ acknowledges that "And instead of professional drivers there will be control rooms. I think that for especially also for social security for public transport a control room will be important"*

> **Q13.** *ICA: "The Dutch labor force in general is quite highly skilled. There has been more demand to the ICT people and also more demand for people who know how to operate the system"*

To meet the demand of the skills, it can be argued that there should be skill supply accordingly from the educational institutions or the professionals should be training themselves. According to the most of the interviewees opinions skill supply can be met if the labors are encouraged to take higher education, re training them and inventing new goods and services on a short run. Later the same educational system being included in the curriculum and training the labors as per the up to date knowledge will be helping in appropriate skill supply.

> **Q14**. *ICA: "For lower skilled workers they have to re trained or they have to be reeducated for certain particular jobs. For example if you consider freight transport industry, there has to be driver in spite of the autonomous truck or truck platooning driving around. There has to be attendees in an autonomous vehicle. The driver should be always in position to monitor the vehicle status".*

Skill mismatch types

As one of the objective of the research was to find out how the skill mismatch affects the labor market in The Netherlands after introduction of AVs. It was also important to know which type of skill mismatch would result after the highest level of automation of AVs. All the interviewees acknowledged that the five types of skill mismatch i.e. *skill shortage, skill gap, skill obsolescence, over education or under education and over qualification or under qualification* would be occurring the labor market once the highest level of AVs are introduced.

Interviewees claimed that due to the competition between the companies there will be demand for employees by the firm with particular skills and educational background. He claims that this is due to the skill shortage at the firm, as the employer does not a firm specific or job specific knowledge. While interviewing the academician (ICD) of the transport and planning department he claimed that this skill mismatch and skill gap will be a great concern in the road transport as there will need of software skills to operate an AV truck. Also one more academician (ICJ) claims that there will be occurrence of skill gap in tech jobs and in the fleet management there will be skill shortage in operating AV truck.

> **Q14**. *ICB: "There are possibilities to have shortage in skills, because the employee doesn't have the firm specific or job specific knowledge."*

> **Q15.** *ICD: "More generally, I think that skill shortage will be a concern in road transport (e.g., trucks) as special software skills and procedural skills may be needed in the operation of automated trucks (cf. airline pilots). Think of challenges in docking and platooning"*

> **Q16.** *ICJ: "There could be skills shortages in these tech jobs. There will be skill gap in fleet managing companies. This means I don't need drivers anymore and I need people who can just care about the vehicle"*

The interviewees mentioned more about the skill obsolescence, as this skill mismatch is more seen in the labor market. The most of the current skills done by humans will be completely taken over by the machines. The respondents claimed that the biggest challenge would be for the drivers as their main job will be driving which will be taken away from them. The skills will be diminished and some might not be even used in the future scenarios. One of the interviewee gave an example of how the horse carts being replaced by the steam engine cars, which made horse cart riders obsolete. The job that uses physical and manual skills are going to be completely automated and making the people and their skills in this sector will be completely diminished and making them unemployment.

Q17. *ICG: "Well, if you have the highest level of automation, then I don't see that you have any old forms of mobility still effective, or still valid. So I don't think there's any room for normal cars anymore. Few of the tasks such as dynamic tasks are done by the system; the fallback is done by the system"*

Q18. *ICC: "If I go back to the five elements of skill mismatch, skill shortage or skills obsolescence, these are different between different industries. So for example, some industries will not have the issue with the skills that were previously used in the job and now no longer required or the skills diminishing with time."*

Some of the interviewees expressed their concern of leading skill shortage or skill gap because as some of the employees at the workplace will be overly educated or their education level will not be meeting to the required level of skill and job. One of the academicians (ICA) claimed it has been from the history of technology development and the same will be applicable to field of AVs. He expressed that some of the employees education level will be so high that they will not be having their job matching their skill in their home country and they move to different country to match their skills sets. There was also other interviewee who supported this claim, the expert ***(ICC)*** from the labor market responded that The Netherlands are having high skilled labors and the country is prepared for AVs. Hence it is very minimal to see over education problem in The Netherlands after the AVs are introduced. But however under education might be seen in some of the industries as some of the labors will not be having certain degree or education level to work on AVs.

Q19. *ICA: "Now, there is a skill mismatch problem but this is actually the other way around. That is there are many highly educated people and there are no jobs. So for them, they move to the Netherlands or to Germany. However Dutch labor workforce is quite highly skilled and thus over education will not be a problem."*

Q20 *ICC: "So considering the case in The Netherlands, it is quite prepared for things like that, the labor force on an average is bit more high skilled and the industries are more of high end. In Netherlands on an average the people are educated, more skilled. Definitely these things will be impacting the skill mismatch."*

Q21 *ICD: "At the same time, the drivers will still need to be able to drive manually, which is a skill in itself. Hence, I think the demands on drivers will increase, causing some under education and under qualification. For example, one may need at least a BSc degree for operating an automated truck."*

Also the interviewee's claims that not only over or under education will be leading to skill gap or shortage but also if the employees are over qualified are under qualified there will be disruption in the labor market after the AV introduction. The respondents explained that due to the change of skill set for truck or bus drivers, they are under qualified to operate the autonomous truck. This makes the drivers to develop more skills and update to the current trends to get back into the labor market. The under qualification can be quite related to under education as the workers who are under educated will be under qualified. One of the

interviewee ***(ICG)*** responded that the workers should be qualified to do certain jobs such as monitoring the AVs from the control rooms. He claims that one should be having a PhD Degree to monitor the system. If you are under qualified then this creates demand for more workers and leading to unemployment.

> **Q22.** *ICG: "So in that sense, the complexity of the operation of the system needs to come down considerably. Otherwise, we need people with a PhD in monitoring the system and you cannot come to full scale deployment"*

Skill categories

The interviewees was asked about which type of skill categories will be in demand and decreasing after the introduction of AVs on the basis of the skill categories listed by Mckinsey global institute. Maximum of the interviewee had an opinion that there will be a great increase in technical skills in the field of software, driving and monitoring skills. Also they were concerned about the physical and manual skills which will be getting outdated as maximum of the skills will be taken over machines, like lifting jobs at warehouses, sea ports and many other places, as most of the jobs will be replaced by automated vehicles. However, they claimed that there will be increase in social and emotional skills. One of the interviewee responded that even though the automated bus will be driving by itself, there will be a driver or attender present in the bus to greet the people and help the old age people to get in and out the bus. Thus this will be increasing the social interaction between the passengers and the drivers. Also they claimed that due to the increase skill demand in the field of IT industry, managing machines, there will be increase in cognitive skills. As the vehicle automation level increase from level 3 to level 4 there will be need for expert in computer expert on board in the vehicle. If the industries are having cognitive skills beforehand then less the industries will be affected by the automated vehicles. One of the interviewee ***(ICI)*** claimed that at the highest level of automation there is more need of human factor and their emotions. As a passenger one should trust the vehicle all time before getting on board. It can be concluded from the responses of the interviewee that the emotional part of the skill of human beings plays one of the important role in the deployment of AVs to the society.

> **Q23.** *ICG: "Otherwise, we need people with a PhD in monitoring the system and you cannot come to full scale deployment. There will be increase in higher cognitive skills and it will be the most important among the other type of skills"*

> **Q24.** *ICI: "Human Factors plays an important role here, because as long as the human has a role as passenger we have to understand whether people trust the automated car and if humans are interacting with automated cars as pedestrians, we also need to make sure that that interaction is intuitive and accepted"*

4.2.2.3 Winners and loser

This category consists of codes related to industry that will be benefited or labor rise in the particular labor workforce by the introduction of AVs and the industry that will be under loss or loss of labors in the labor market after the introduction of AVs. Exploring who will be the

winners or losers after the highest level of automation of AVs is introduced into the society. The interviewees had different opinions on who will be the winners and losers in the labor market. Among the interviewees there was a general understanding that by the introduction of AVs the employment impact was not just on the driving occupation but much broader than that. All the respondents had were not only considering the negative aspect i.e. elimination of driving jobs in freight and passenger transport industry they were also having positive opinion on creation of new jobs in various other sectors. The viewpoints of the respondents can be seen below.

According to some of the interview, in terms of job creation or the labor workforce there will be a positive outcome if the AVs are introduced in the incremental and gradual manner. It can be concluded from the interviews that the new occupation that will be originating in the sectors will be in need of combination of different skill set which is not available in the current market place. Thus, creating various types of jobs and compensating for the loss created. According to the academician ***(ICA) & (ICB)*** and the expert ***(ICC)*** form labor market there will not be a huge impact on the automotive industry, as there are no much industries originating from The Netherlands. Telematics and software development industry will be finding up rise in the near future. There will be job loss in the delivery industry, service industry and insurance sector, freight and passenger sector. However the academician (ICA) argued that there will loss in the freight and trucking industry but it will not be impacting Dutch labor workforce as most of the truck drivers are from other countries like Poland, Slovakia and others. Hence it will not be great impact on Dutch labor workforce.

> **Q25.** *ICA: "Winners are the electronics and software industry. There is no much impact on automotive industry as there are no much of industries originating from The Netherlands. Telematics will be having an up rise after the introduction of AVs. So, coming to the losers will be the service industries such as insurance, freight transport, passenger transport, taxis and legal experts"*

> **Q26.** *ICC: "For instance all traditional industries, that is highly into R&D intensive industries that invested a lot in innovation and industries that have to do with ICT. These industries in the results that we have calculated also for the Netherlands, they seem to not be losing a lot of jobs as a result of automation, but actually creating new tasks for labor."*

> **Q27.** *ICA: "Although the Netherlands is having a big transportation sector, it is also true that over the past 10 years or so, many of the truck drivers for instance, are no longer Dutch. I mean, there are drivers from Poland who are in maximum numbers. So it might be that they will be affected, but that is not necessarily for the Dutch labor force. I don't think the impact will be very big."*

In terms of labor workforce who will be more affected in The Netherlands will be the delivery sectors, fewer jobs in medical sectors and disabled care centers as the number of accidents will be reducing. Common responses by most of the interviewees were the freight and passenger will be majorly affected by the AVs. But one of the interviewee (ICG) claimed

that the drivers in the freight industry are not worried and they are more eager in looking forward to the AVs and working with them.

> **Q28.** *ICG: "I talked to some of those truck drivers doing truck automation, they really liked it because normally now their job is extremely boring. Now they can work with new fancy technology, which also allows them with other people and you know, these are very curious guys"*

> **Q29.** *ICB: "I think there will be marginal effects across the industries. But it will be big impact in quantitative term. Apart from this there will be impact to delivery industries, like the E bikes, bicycle delivery services that we see around for example deliveroo, thuisbezard and other companies. This has actually become a big sort of in terms of numbers like a non-negligible part of the labor force which might be automated to some extent."*

Almost all interviewee claimed that insurance sector will be more affected after the introduction of AVs. According to them implication will be huge, as the AVs will be safer and occurrence of accidents are less and the owner of the vehicle will not be held responsible if there is any accidents. Manufacturer of the AVs will be held responsible. Also services of police officers will be lowered as the most of the vehicles on road will be AVs and this reduces traffic congestion. One of the interviewee (ICJ) claimed that all the labors with low educational level and skills will also be losing their jobs. Interviewee (ICI) gave different viewpoint on winners and losers. He claims there will loss for professional drivers. But he claims that AVs will be making the commute for normal working people, giving them opportunity to work on the way to office thus increasing traffic on road. Hence there should be a monitoring center or control room at the police headquarters. Here we can see there is removal of police officers but creating new jobs for worker and encouraging them to be trained to new type of skills.

> **Q30.** *ICH: "Again if there's a question that will happen, of course we are talking about truck and lorry industry along with that there's some more workforces as well like insurance, services like police authorities. As the traffic congestion will be lowered and the job of the traffic police will be minimized*."
> **Q31.** *ICI: "All the professional drivers will be affected. Also those who commute a lot, their commute time may become either work time or leisure time. And especially for the commuters I think they will be winners and they will benefit from it. But there is of course also a risk and it's not a risk so much for the labor but more for traffic system that if the travel time becomes enjoyable and if we also resolve congestion at the same time by automating traffic better that may lead to even more traffic. And instead of professional drivers there will be control rooms.*

4.2.2.4 Resistance by labor unions

Whenever a new technology is been introduced, there will be always an opposition from labors. The interview result of rating given by the academicians and expert it can be seen there will be huge resistance by the low skilled labor industry. One of the interview (ICA) claim that

for some of the low skilled workers, this is the only way of income for their living. This hampers their identity and value. Hence they consider this as a threat and try to oppose the introduction of AVs. The interviewee gave example of farmers and miners, how their jobs were affected when the green house farming was introduced and rest of the mines was closed.

Almost all the interviewees claim that in The Netherlands there are many union organizations associated with truck and lorry drivers who will be creating a strong opposition to the introduction of AVs, as the introduction of AVs will be eliminating most of the low skilled jobs in the industry.

> **C32.** *ICH: "Yes, definitely there will be resistance. There will always be luddites who thinks machines that are invented are unnecessary. You will always get lot of objections for new technologies emerging in the society."*

> **C33.** *ICH: "Yeah, this is going to really depend on how companies are going to manage this process. There is always resistance. But I think that some countries are better than others in these processes and maybe the Netherlands will not be the worst one."*

To oppose the above statements one more interviewee (ICG) had a contradicting statement. He claims that there will not be opposition by the workers as the introduction of AVs will be creating new jobs in a gradual manner. And the educational institution will also be in line with the updated technology and thus helping the low skilled workers being trained to the new technology and not losing the job. Also, expert (ICC) from the labor market supported this claim that the union organization in The Netherlands has a good relationship with the government and they trust the government that they will be helping the drivers and thus not creating much a chaotic situation in the future.

> **C34.** *ICG: "I don't expect a lot of resistance from them. So it's going to create many new jobs and it will be a gradual process in which drivers and their current jobs will still remain to be there and the new generation and also the low skilled workers will be able to work with our system. So I think already in the schools and Institute's for education, this is already going on. So, I don't think I'm not expecting a big opposition"*

> **C35.** *ICC: "Definitely they would not welcome it. But because we're talking about the Netherlands, I don't really expect some mass resistance. In Netherlands we have quite strong unions, but the unions are always in good relationships with the representatives of the employers and also the government."*

4.2.2.5 Skill mismatch duration

This code category has just two codes in it and the same category code was used as the abstract code. In this research we are examining if the skill mismatch is a problem to a labor market after introduction of AVs. Every problem has a timeline. As the time increases the

problem density decreases. The same was examined with the interviewees in the case of skill mismatch, to check if the problem is short term problem or a long term problem.

According to most of the interviewees they considered the skill mismatch as a short term problem. The same can be inferred by the rating result shown in the "analysis of data from PART A of interview" in this report. Some of the interviewees acknowledged that in Netherlands, the problem might be for 5 or 10 years. But it all depends on how soon the AVs will be introduced to the market. If the AVs are introduced immediately it will be creating shock to the labor market and it will be hard to accept the changes for the society. Analogy on invention of light bulb was given, on how its invention eradicated usage of candle light and then the people were getting used to the electric bulb. One of the interviewee responded that there was a similar problem and resistance when automation was introduced and used in various sectors. A decade ago labors were opposing it and now although it has taken out some of the jobs from the labor market, it also created numerous other jobs and helped labors to upgrade their skills and made a huge progress in advancement of other innovation and technology. The same will be happening in the case of the AVs when they are introduced to the society. The respondent suggested that the best way to minimize the problem or not creating chaotic situation in the future is to train the undergrad student, upgrade educational system and institution.

> **Q36.** *ICB: "To the extent that is a problem it's a short term problem. Up to five years or decade this problem might persist. Business cycle frequency would be longer*."

> **Q37**. *ICC: "I agree that it is a short term problem; it is definitely not a long term problem. You can deal with that. We've dealt with this in the past with different types of automation. For example, we used to have horses and the horses were out of the labor force and we have the cars to commute around. It can take some time to get adapted widely. So if you would just immediately introduce automation, you make it a short term problem to deal with, it's a shock to the labor market. And the labor market is slow and cannot adjust very fast. And if you do it step by step the problem can be minimized."*

On a longer period, people will be updated along with the advancement of technology thus minimizing the skill mismatch problem. There is a need of huge collaboration between the government and other stakeholders who are expertise in development of AVs. This helps in having time management and thus having correct timeline in introduction of AVs to the society.

4.2.2.6 Government and employer involvement

Government and employers/firm being one of the main stakeholders who is responsible in introduction of AVs to the society, it is important for them to work together to minimize the skill mismatch problem. This code category involves two codes namely, *Government involvement and employer/firm involvement.*

Government intervention

Skill mismatch can be shaped by two key factors and one of the key factors is policy environment by government which helps in minimizing the distortion. Interviewees gave a strong opinion that the involvement of government will be a useful step in reduction in skill mismatch. The interviewee (ICA) acknowledged that the government policy especially for low skilled workers will be helpful for them to get retrained and reeducated, thus minimizing the unemployment rate in Netherlands. Policy like relocation of low skilled workers to high job prosperity location will help them to get employed. In Netherlands, there is flexible labor market. The government is keenly observing these developments on AV and improving education level to meet the skill demand.

Interviewee (ICC) claims that if the introduction of AVs is led by free market, then they will be more oriented towards making profit to themselves. Hence to prevent the marker failures, there is a need of government intervention. This helps in educating and training people accordingly. Respondent (ICB) claimed that there are only limited measures that educational institutions can do in mitigating the skill mismatch problem. It is much more important to introduce industrial policy to change the type of jobs the labor workforce demands. Also subsidized training can also be given to the low skilled labors to enhance their skills depending on the requirement.

> **Q38.** *ICA: "I think it is important to have supportive labor market policies, especially for the low skilled workers who will become unemployed for some time and have to retrain and to redevelop their skills. Suppose people who have been employed in North of Netherlands and who need to come to south of The Netherlands, government can help them to re locate to the place where there is high job prosperity."*

> **Q39.** *ICC: "The elements from the policy perspective they do exist here and you have quite a flexible labor market. You do have flexible education system. The government seems to be paying attention to these developments and protect the labor force"*

> **"***We talk a lot about market failure. But it's basically what the market fails to deliver. And that means that you require government intervention or like regulating the market corrects for these market failure. If you just leave it to the free market, let's say the free market only cares about profits, profit maximization; you will get too little education. So as the government you need to subsidize this expansion."*

Academician (ICG) acknowledged that it is the responsibility of the government to make sure that the drivers who will be monitoring the AVs should be clearing the preliminary test or exam conducted exclusively for AV trucks. This motivates the labors to develop skills and educate themselves to meet the skill demand.

> **Q40.** *ICG: "I think in the operation of the vehicles that will be new training required for the drivers. So, for instance, drivers now, driving with autopilot is not part of your*

driving examination. But in the future, the driving without autopilot will be part of your examination. But this is a legal process and to introduce that into the examinations and you need to have some European standardization for that."

These precautionary measures and intervention of the government will definitely help the reduction in skill mismatch. But along with that it is also the responsibility of the individuals to train themselves and update accordingly with the advancement in technology. Leading to right balance between demand and supply of skills in the labor market.

Employer/firm intervention

Apart from the involvement of government in reduction of skill mismatch it is also necessary that if the employer/firm is involved in this process. This collaboration or individual step as a firm will be creating more motivation in labors to get trained and updated along with the trend of advancement of technology.

One of the interviewee (ICB) claimed that currently most of the firms are outsourcing their jobs to external agency instead of doing in house. Instead if the job is given to the low skilled worker of the same firm has lost the job due to the AVs, there will be reduction of unemployment. In the trucking industry, after the AV trucks are taking over the job, as a firm they can retrain their drivers to different specific jobs or encourage them to take up new job in the new systems which have been emerged. By the opinions of each of the interviewee on intervention of employer to mitigate the problem of skill mismatch when the highest level of automation of AV is introduced is to retrain their employees and encourage them to develop new skills apart physical and manual skills and motivating them to develop cognitive skills.

Q41: ICB: *"The employers always want to outsource their education to the state and not pay for themselves. But to the extent that they can actually educate their own employees, they can take certain measures to minimize this skill mismatch"*

Chapter 5: Discussion and Conclusion

This research was an attempt to examine how the introduction of highest level of automation will affect the labor market in The Netherlands. The result obtained from this research can be taken as precautionary measures to minimize the negative effect on labor market after the introduction of highest level automation of AVs. This chapter first discusses the results that were obtained from the interview and answering the main and sub research questions. Further, limitation of the current research conducted and the recommendation of further research which can be conducted to overcome the limitation is discussed.

5.1 Conclusion

The main objective of this thesis research was to understand the potential impact of autonomous vehicles on labor market in The Netherlands. The main research question of this research was:

"How might the introduction of autonomous vehicles influence the labor market related to potential changes in skills and job types in the Netherlands?"

Based on the interviews, the main conclusion was that the influence of highest automation level of AVs on the labor market related to skill and job types is minimal in The Netherlands. Interview resulted in various factor related to skill mismatch on how it will be affecting the labor market and outcomes due to skill mismatch in certain labor workforce. Using these factors and the outcomes, answer to the main research question will be further explained.

From the analysis of the interviewees result it is seen that the skill mismatch is not the main factor which affects the labor market, but is one of the factor which influence the labor market related to skills and job types. The opinion of the interviewees varied on this topic. Some of them disagreed that it will be affecting and not being a main factor, however some of them agreed that it will be definitely a main factor which influence the labor market. But, maximum of the interviewee agreed that it will not be a huge concern in The Netherlands if the AVs are introduced in a gradual and incremental way into the society. So, that this gives certain period of time for the society get adapted to the new technology and accordingly develop new skills. Even though if there would be a skill mismatch problem, according to some of the interviewees the problem could only persist for shorter period of the time. However some of the interviewees gave opinion that it may persist longer than expected and it may depend on which intervals the AVs are introduced to the society. Some of the interviewee had a strong opinion that people with low education level and lower qualification will be finding hard time to find a job matching their skill and it is termed as under qualification and under education. Furthermore they noticed that skill mismatch will be a major threat to the low skilled labors, as their education and qualification will be low. The main affected labors would be the drivers as their skills will be getting obsolete and only job of driving will be completely automated. But, if the employers can help them in retraining and find another job, the unemployment rate can be

reduced. Each interviewee appealed that there can be multiple measures taken to minimize the skill mismatch if the government and employers/firm are working together. The government policy especially for low skilled workers will be helpful for them to get retrained and reeducated, thus minimizing the unemployment rate in Netherlands. Upgrading the educational institution, subsidized training, relocation, industrial policies, innovation policies and other labor market polices. Apart from all these policies of retraining, reeducating labors and finding alternative occupation to match the skills, one of the ways to mitigate the skill mismatch is that if the AVs are introduced in an incremental or gradual manner to the society, the people will be having time to adapt and accordingly update their skills and educate themselves to meet the skill demand. This will make sure that there will not be an abrupt change in the labor market after the introduction of AVs.

Apart from the effect on individuals, almost all the interviewees indicated that in The Netherlands there will be effect on certain types of labor workforce in the labor market. They pin pointed that there will not be any effect on automotive sector in The Netherlands. But, there will be a significant effect on electronics and software industry as maximum part of the AV will be dependent on the software. There will also be increase in demand in the telematics services as the MAAS concept will be increasing in the near future. From the interview result it was seen that maximum of the interviewees were concerned about the freight sector as most of the drivers will be unemployed. Also, there will be negative impact on repair and servicing sector, medical sector where the care taker for disability will be decreasing as there will be substantial decrease in number of accidents. Logistics industry will be highly affected as maximum of the job will be carried out by the AV trucks and other type of automated vehicle. The AV introduction also affects the delivery services like deliveroo, thuisbezard, there will be huge decrease in e-bike delivery system, food delivery and other type of delivery services. Since, the case of highest level of AVs are still hypothetical, it can be predicted from the historical technological advancement, that there will be complementary task which will be emerging as the timeline of the AV introduction improves.

It can also be concluded from the result that interviewees also suggested few types of skills and job types that might be affected due to the skill mismatch factor. The most common result from each interview was that there will be a huge decrease in truck, professional and lorry drivers. There might be possibilities that the driving jobs might get obsolete. But, if the AV truck is malfunctioned and come to state of halt, it is essential to have an attendee to operate the AV truck. Hence there will be increase in demand for attendee for AV trucks. Accordingly, there will be less demand for bus drivers too, although to have social skills with passengers and helping them if they are having trouble during the journey, there will be increase in demand for attendee. The attendee for both the truck and bus driver should be having minimum qualification and certain training with skill to operate the AV bus and truck. As the AVs will be taking over the road, there will be minimal amount of traditional cars on road and hence demand for motor vehicle mechanics and repairers will be decreased. Also as the AVs decrease the traffic accidents, there will be decrease in caretaker's jobs at the hospital. As the amount of

AVs increase on road, to manage the traffic there will be increase in jobs in control rooms of vehicle monitoring in traffic management. As maximum of the AVs are of software components, there will be huge demand for people who are well versed with ICT skills like software engineer robotics, autonomous driving algorithms, AI and deep learning, diagnostic repair technician and many more.

5.2 Discussion

In the initial stage of the research, four research gaps were identified. There were no particular research done to understand how the introduction of highest level of automation will influence the labor market related to skills and job types based. There were no research how the skill mismatch factor will be affecting the labor market after the introduction of highest automation level of AVs. Based on the findings from the result, this section reflects upon how this research helped in fillip up those gaps.

A conceptual model was developed to find the relation between the introduction of AVs, labor market and skill match factor. This model can be seen in the section 3.6. From the empirical results obtained from the semi structured interviews it can be concluded that there is no changes in the conceptual model as the results reflected the same as the model. The major remarks from the result that if the introduction of AVs are in an incremental and gradual manner there will not be a skill mismatch problem in the labor market when the highest level automation of AV are introduced. Hence the skill mismatch problem is only a short term problem if the relevant skills and job types are developed in the initial stage of level of AVs, and then there will be linear development of skills and job types along with the development and introduction of AVs. If all the stakeholders are involved in the process, then there can also be a possibility of minimizing the skill mismatch problem. If the government and employers are involved in creating policy on retraining and upgrading the level of education at institutional level, there can reduction in unemployment.

The unique feature of this research is that methodology involved. There are only few researchers who have done semi structured interviews to understand on how the AVs will be affecting employment. And none of the research has conducted semi structured interviews with the academicians as the main methodology. The sample size of the research was not much of expert in labor market; the confidence level of the result was not high. The precision level was comparatively low. The sample size was limited to more number of academicians from transport and planning department, only two from economic and innovation department and one expert from labor organization. More insights were needed from academicians who are expertise in labor market.. Multiple academicians were approached from different universities all over The Netherlands but due to their unavailability, the sample size was restricted to academicians mentioned in section 2.2.2. The input from the academicians of transport and planning was more focused on effect on employment in transport sector. There were limited valuable information gathered from academicians of economics and innovation department and more insights on effect on overall labor market. There were few instances where there

disagreement between the academicians of transport and planning department. For example, out of 8 academicians 5 of them agreed that the skill mismatch will be a major concern in The Netherlands; however the other two concluded that skill mismatch will be a major concern. There were other instances where there were two different opinions from the academician of E&I department. For instance, one of the interviewee agreed there will be resistance from low skilled workers, whereas the other had a neutral opinion. The next sample size was chosen from the labor market section. Multiple labor organizations were approached for the interviews. Only one labor organization accepted the invitation and accepted to give interview. The sample from the labor organizations from the Netherlands was limited. The common reason for rejection of the invitation for interview was, as there is no currently fully fledged AVs running on road, there has been no much research being done on the socio economic impact in the Netherlands and hence there were limited number of expertise available for the interview.

However since the highest level of automation is non-existence and still in testing phase, it was found appropriate to conduct exploratory study and gather data from relevant expertise. Identification and addressing the concerns regarding effect of AVs on labor market would help certain stakeholders like government and employers. But as per the general opinions from the academicians and the expert the skill mismatch will not be a problem in The Netherlands and the effect of highest level of AVs on labor market is very minimal.

5.3 Limitations of the study

As any research this research too has certain limitations. Some of them are listed below

- The conceptual model developed for this research was by using the literature from the field of technology and policy, which was then modified to fit the technology in the transport domain. There are many other factors which affect the labor market apart from skill mismatch factor
- As the topic involved “Autonomous vehicles”, many interviewees acknowledged it to be hypothetical scenario and the answers were given based on the hypothetical assumption considering the situation that highest level of AVs on road will not be possible
- This research mainly focused on how the AVs will be affecting the labor market related to skills and job types, there are many other factors like wage effect, GDP of nation, number of jobs, wage inequality which affect the labor market of the country
- Out of the 13 interviews conducted, the subject in the sample was more of academicians from the universities. If the sample size were working people from labor workforce, we will be getting more insights on more detailed explanation on actual effect on labor market by the AV introduction.
- Various labor workforces like TNO, DAF trucks and more were contacted for scheduling an interview for this research. Due to the company policy and due to the sensitive topic which involved “effect on employment by AVs”, the sectors were not in position to disclose the confidential information

- We used judgment sampling to find relevant subjects for the research. Due to the busy schedule of the experts and academicians who possesses great expertise in the AVs effect of labor market refused to participate and was hard to reach
- Out of the 13 respondents, 5 interviews were done face to face and others were by e-mail, Skype and telephonic medium due to recent breakdown of COVID-19 globally. As there is lot more advantages by interviewing face to face in natural settings, having use of telephonic conversation and Skype conversation turned out to be limitation for this study. Some of the interviewees were not confortable in the usage of Skype.

5.4 Recommendation

Due to certain limitation mentioned in the previous section there is some provision for future research who will be interested in conducting research in this study

5.4.1 Recommendation for future scientific work

- The interview was mainly focused on academicians from universities and expert from labor market. For future study the researchers can approach the industries of various sector and gather information from the experts
- The sample size of the research can be increased. This research was only limited to 13 interviews. This helps in getting more information on AVs effect on labor market
- This research was mainly focused on how and why questions (qualitative approach). There can be provision for, by how much and how many types of questions (quantitative approach via economic modeling). This might help in achieving more confidence level in the result.
- There are other factors which affect the labor market such as wage effect, GDP of the nation, wage inequality, number of jobs, and change in earnings due to introduction of AVs. Among these, if the researcher want to quantify the number of jobs being affected in each industrial service sectors, then the best way of carrying out the research is by quantifying how many jobs are being affected after the introduction of AVs of highest automation
- Approach used by Acemoglu and Autor can be implemented in the future research to have an overview of labor market trends, with an emphasis on changes in the earnings distribution, in the distribution of employment by occupation, and in the allocation of skill groups to job tasks.
- Since the research based on hypothetical technology and all the literature are being concluded based on assumed scenarios. Once, the next of AVs i.e. level 3 and level 4 are introduced it will be much easier to gather information and conclude them
- The research was mainly focused in The Netherlands, the impact on the labor market has to be seen as the global impact and it differs from country to country. So generalizing the result would be difficult part of this study.

5.4.2 Recommendation for policy makers

Policy makers are responsible for development of policies, laws and regulations which influence AVs effect on labor market. Currently as per the report, as a country Netherlands are at the top of the list that is prepared for AV revolution. Also the policy law makers can influence low skilled labors to accept the AVs and minimize the resistance.

- Exploring strategies and policy options to enhance positive job impacts and minimize negative impact in the labor market
- This is highly challenging task and it requires collaboration between the multiple stakeholder, including government, labor workforce and general community.
- Education improvement to minimize the under education and under qualifications problem
- Policies and regulations that protect low skilled workers from getting unemployed

5.4.3 Recommendations to businesses

There is no much recommendation to the businesses, as these are the stakeholders who develop the technology. The employers who are apart from the developers of the technology have to be in track with the pace of technology. As the new trends of technology like AVs kick into the market, there will be subsequent effect on the labor market. Hence the employers in the respective businesses should train their employees as per the new trends of the technology.

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Appendices

Appendix 1: Overview of descriptive statics table

This appendix demonstrates overview of descriptive statics table from Part A of the interview. This table was generated from JASP software.

Table 10: Descriptive statics table of Part A of the interview

Sl No.	Questions	Descriptive statics				
		Mean	Median	Mode	Std. Deviation	Skewness
1	After introduction of highest levels of AVs, skill mismatch is one of the main factor which affect the employment in the labor workforce	2.692	3.000	3.000	06304	-2.051
2	Skill mismatch will be a barrier between the employers and employees after the introduction of AVs of highest level of automation	2.769	3.000	3.000	0.5991	-2.682
3	Skill mismatch will be a huge concern in The Netherlands after introduction of AVs	2.769	3.000	3.000	0.5991	-2.682
4	After AV adoption, skill mismatch in the labor workforce is a short term period problem	1.538	1.000	1.000	0.7763	0.6163
5	After AV adoption, skill mismatch in the labor workforce is NOT a long term period problem	1.308	1.000	1.000	0.6304	2.051
6	The effect of skill mismatch on labor workforce is similar to each levels (0 to 5) of automation of AVs	2.692	3.000	3.000	06304	-2.051
7	There will be resistance from workers in the traditionally low skilled industry after introduction of AVs	1.308	1.000	1.000	0.6304	2.051

Appendix 2: Detailed decisive code books

This appendix gives the reader a detailed decisive code book list

2.1 Introduction of AVs

Table 11: Codes under category introduction of AVs

Code	Grounded
Unemployment	27
Minimal issue	23
Job replacement	9
Job specific knowledge	7
Unconditional situation	6
Unskilled workers	6
Increase in labor productivity	6
Low unemployment rate	5
Raise in inequality	5
High skilled labor force	5
Main factor affecting employment	5
Skill biased technical change	5
Incremental process	5
Gradual introduction of AVs	4
Skeptical situation	4

2.2 Skill mismatch effects

Table 12: Codes under category skill mismatch effects

Code	Grounded
Skill shortage	30
Skill obsolescence	30
Skill gap	25
Over education	20
Over qualification	20
Under education	15
Under qualification	15
Cognitive skills	10
Skill demand	10
Skill supply	10
Skill mismatch difference	9
Minimizing skill shortage	8
Physical skills	8
Social and emotional skills	8
Skill training	7
Skilled labors	7
Skill development	7
Dependent factor	7

2.3 Winners and losers

Table 13: Codes under category winner and losers

Code	Grounded
Freight and transport industry	19
Automotive industry	15
Financial service	9
High educational level	9
Supervision	9
Technical skills	9
Truck platooning	9
Trucking industry	9
Beneficial labor workforce	8
Unaffected labor workforce	8
Small problem to drivers	6
Non beneficial labor workforce	6

2.4 Resistance by labor unions

Table 14: Codes under category winner and losers

Code	Grounded
Low skilled job	15
Low education level	14
Unskilled workers	10
Policy protection	9
Strong union	8
Resistance by low skilled workers	8
Good relation with government	5
Positive response by drivers	2

2.5 Skill mismatch duration

Table 15: Codes under category skill mismatch duration

Code	Grounded
Short term period	13
Long term period	9

2.6 Government and employer's intervention

Table 16: Codes under category government and employer intervention

Code	Grounded
Retraining	30
Educate labors	22
Creation of new tasks	19
Changes in educational system	18
Compensation to low skilled workers	9
Emergence of new occupations	9
Subsidized training	9
Emergence of new skills	9
Government intervention	8
Increase in educational level	8
High regulation countries	8
Labor protection	8
Policy protection	5
Relocation	4
Regulation in reducing skill mismatch	4
Restoration of old skills	4
Trust between employee and employers	1
Outsource	1
Less regulated countries	1
Awareness creation	1

Appendix 3: Interview transcripts

3.1 Interview transcript (code ICA)

Interview code: ICA

Interview medium: Face to face

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

I think that that the skill mismatch problem will probably be quite limited. That's what I would think. The Dutch labor force in general is quite highly skilled. There has been more demand to the ICT people and also more demand for people who know how to operate the system. However there will be lower demand for unskilled drivers and they will be affected but it would not be a bigger impact on labor force. Although the Netherlands is having a big transportation sector, it is also true that over the past 10 years or so, many of the truck drivers for instance, are no longer Dutch. I mean, there are drivers from Poland who are in maximum numbers. So it might be that they will be affected, but that is not necessarily for the Dutch labor force. I don't think the impact will be very big. Also for instance there might be affect in production process of the cars. I think if you look at it again from the Netherlands point of view the current unemployment rate right now is very low. It's a general shortage of employees. So, I mean, let's say, unemployment is about 4%. And it could be that people who are unemployed lack necessary skills required by the employers. All industries are saying that it is becoming more difficult to find employees. It is also true that achieving unemployment rate of 2% is impossible as there will be always people who are getting graduated every year and who are looking forward for a job. Suppose you are highly skilled though you still take couple of months before you find a job. So in this position you will be entitled as unemployed. So, achieving 4% unemployment is the minimum or lowest number possible to achieve. It could be very specific firms that there is a skill mismatch and they may hire migrants from China or India to work for the firm. Right now unemployment is low, the Dutch labor force is aging, and again this is a gradual. But let's say the next 10-15 years I think it is probably true that the Dutch labor force will decline. But I think that whatever is happening here, to the extent that there is a loss of jobs. It is probably, in line with the decline in the labor force as well. So, I will be taking a neutral stand here and do not expect a very big change. Currently it's not that we have structural unemployment and quantify number of people who do not have requisite skills and problem here is quite manageable.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I think it's a very different in Europe, between different countries. So if you take the 10 Scandinavian companies and the Netherlands and Germany, you will find it's mostly the same. Like there is not a skill mismatch problem and unemployment is also not so high. But if you go to countries like Spain and Italy, you will find unemployment is very high. Now, there is a skill

mismatch problem but this is actually the other way around. That is there are many highly educated people and there are no jobs. So for them, they move to the Netherlands or to Germany. There are people who are highly educated, highly skilled because of lack of employment, they move to other countries, which we term it as brain drain. Many engineers from other countries go to Europe and US to find job to their level of skills and educations. Many workers from Easter European countries like Poland, Romania and many more come to Netherlands and Germany to do low skilled works like agriculture, transportation domain, and building construction. Now, to the extent that it is in transportation, if we have autonomous vehicles and the demand for drivers goes down and therefore, it means that they will have a problem, especially for the lower income European countries.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Winners are the electronics and software industry. There is no much impact on automotive industry as there are no much of industries originating from The Netherlands. Telematics will be having an up rise after the introduction of AVs. So, coming to the losers will be the service industries such as insurance, freight transport, passenger transport, taxis and legal experts. In addition to this we have a big transportation sector. Let's say the number of cars or let's say the volume of transportation stays the same. But what changes is instead of the drivers we now have autonomous vehicles. So, let's say, if I operate a wholesale firm and I need your transportation services. If you give me the same transportation services as before, but now using AVs then I am not affected much. Unless you think that the cost of transportation can go down, without drivers. But it is also true that before you can do all this you need a lot of software development and you need a lot more infrastructure building you. So, in a sense, again, especially initially it may not be cheaper

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

There will be increase in demand for high skilled programmers and coders and so on. So, the biggest change will be that the demand for drivers will go down. SO the lower skilled workers will be in threat. There will be diminishing of skills and some might not be even used for the future work. For example, earlier people were having horse cart and gradually as the technology got innovated the horse cart was replaced by steam engines and then later to internal combustion engines replaced steam engines. Thus, the people who were skilled in those particular domains got obsolete or diminished.

Q5: Will it be similar or different for each labor workforce?

It will be different for different labor workforce, as there will be more of a cost of adjustment because of diminishing of skills. For lower skilled workers they have to re trained or they have to be reeducated for certain particular jobs. For example if you consider freight transport industry, there has to be driver in spite of the autonomous truck or truck platooning driving around. There has to be attendees in an autonomous vehicle. The driver should be always in

position to monitor the vehicle status. He has to be having certain qualification or skill to operate the vehicle. Hence he has to employees with lower education or qualification might not be suitable for job. Coming to the software and telecommunication industry, depending on the progress of the AVs the employees will be trained. Due to the competition between the companies there will be demand for employers with particular skills and education background.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

I think there will be a readjustment process and demand for high skilled people. And there will be problem offering trainings for the drivers. But looking towards long term scenario according to me it is quite manageable like as I said the labor forces is sort of not growing or going down and unemployment is quite low. So, suppose I'm a driver and I'm losing my job, I look around and there are jobs where I have develop more skills and train myself for the job. I am motivated to look for more jobs or different domain of work other than driving jobs. It may be in energy sectors, constructions. There is a possibility of readjustment but it is not a major upheaval I would think. At an individual level it is not a small thing, but economy as a whole it is manageable.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

Probably the skill mismatch will be become more intense and much bigger along the level from level 0 to level 5. But, even at level 5 like I said from the economic point of view as a whole it is quite a manageable process. Considering the current level 1 and 2 of autonomous of vehicles, the workers are not replaced completely. There has been retraining programs conducted among the employees by the employers to retain the worker and maintain capital of the company.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

I already indicated that the problem is not a very large problem; it is a short period problem. For instance it might be a five year problem, but it is all dependent on how fast or soon the AVs are being introduced into the market. And now suppose we introduce that system, and then it will be a shock as it will be a very drastic change from one mode of transportation to another mode. It is also true that if there is provision of re schooling and re training with economy doing well. On a longer term the problem is very small and quite manageable at The Netherlands.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Definitely there will be resistance from the low skilled industry labors. For many people the job at the trucking industry is the main bread and butter for their living. It's a way of life for the people of these kinds of skills. It will be clearer if I'm taking the example of farmers. For instance, with farmers, farming is a way of life. If you touch that activity, you're not just telling

people that you are touch their jobs but you are touching their identity, you could say. That's the same with drivers I think. If we fire all drivers from the trucking industry by using autonomous vehicles, then it will be painful for drivers because they basically have to give up the identity. It is different for them, from being a driver to be in an office which they would not be like. That's one of reason because of the identity and way of life. Another example would be around 40 years ago we had coal miners, it was physical heavy work and minors were proud of their job and it was the part of their identity. When mines were closes, people hated this because it led to loss of job, income and identity. And there are high chances that the drivers and other low skilled labors will be experiencing the same thing here. The second reason is that they may have doubts about what measurements will be taken during accidents, what are the safety measures and trust among the AVs. Drivers are not so strongly unionized and thus the resistance will not be strong and organized.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

I think it is important to have supportive labor market policies, especially for the low skilled workers who will become unemployed for some time and have to retrain and to redevelop their skills. Suppose people who have been employed in North of Netherlands and who need to come to south of The Netherlands, government can help them to re locate to the place where there is high job prosperity. Some of these supportive measures will definitely help the employees to meet the job which perfectly match to their profile.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Yes they will also be having some role to play along with the government to mitigate the skill mismatch. Suppose you are a transportation firm and after the introduction of AV, the firm will not be in need of extra drivers. As a firm you can retrain some of the drivers, to take on new jobs in the new systems which have been emerged. That's also in the interest of the firm. But the idea is that you as a firm you are committed, I mean, there is a structural change. You basically commit to your worker and thus on the other side the workers will be welcoming it.

3.2 Interview transcript (Code ICB)

Interview code: ICB

Interview medium: Face to face

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

I don't think it would be a major factor, and other things like the state of aggregate demand, the level of wages and the extent of public expenditure whether it is expansionary or contraction. Events in the international sphere, whether if the global trade is booming or not. These are all things that will be much more important for the employment situation in the Netherlands.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I would think that in developing countries, there will be very little demand for highly educated people. I think that the sort of software that will run AVs will be developed in a few cities around the world. Maybe city in China, then the Silicon Valley and then towards the other cities around the world, maybe have to say, Well, probably the Europeans will succeed and build something somewhere in Europe. For the sensors and the processors I think from Germany it's strong, but I don't know if the Netherlands actually produces like has a sort of high tech sensor for industry. So, yeah, I think it will differ from across countries, and some countries are better positioned to reap the benefits. For hardware, I mean the same countries, nowadays produce all kinds of IT equipment. First stage of production might be in China then assembly. In, also in China then get shipped off to Taiwan or other countries and there's the next stage like so on. Yes it will differ from country to country but it's hard for me to say, which country will be benefited more. Whatever sort of drives macro economic investment expenditure will be the driver of the status employment and investment expenditure has always been a very difficult, very early to explain for the economists.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Yeah so immediately Of course comes to our minds truck drivers and taxi drivers. So, maybe it will be possible to drive a couple of trucks which is named as truck platooning. Greeting somebody and telling somebody what is where maybe is a little bit of a people's job, but presumably some job this they are maybe even the majority will be lost. I don't think that, the Dutch IT industry will benefit so much, unless there is an IT seem emergence. Dutch industry is not well versed with car industries. I think there will be marginal effects across the industries. But it will be big impact in quantitative term. Apart from this there will be impact to delivery industries, like the E bikes, bicycle delivery services that we see around for example deliveroo, thuisbezard and other companies. This has actually become a big sort of in terms of numbers like a non-negligible part of the labor force which might be automated to some extent.

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

Since I said that I doubt that there will be lots of new sort of software jobs created. And I'm also not sure if there is an industry for sensors and computer processors. I doubt there will be much of additional demand for high skilled labor. The people who lost their job in driving industries, they will be little educated and may have to find jobs in low productive jobs. There are possibilities to have shortage in skills, because the employee doesn't have the firm specific or job specific knowledge. But maybe this can be learnt on the job. The other type would be there is still need of higher education for training purposes of new technology which is not been introduced to the system. Also, there are possibilities of under education which is similar to skill gap, because many university alumni are under educated and not trained to the current world technologies. I'm not sure if sort of firm specific or job specific knowledge changes the requirement so much. To the extent if there are high tech sector's emerging, they fear that they don't have enough university graduates with those skills giving rise to under education problem. Many low skill and low educational job might disappear. They have to move to other low productivity sector jobs.

Q5: Will it be similar or different for each labor workforce?

AIs, AVs impact, different jobs differently because, routine operations can be automated. The drivers have often had low educational attainment to begin with. And they will probably be attractive, only for employers who have, you know, low productivity service jobs, open, and where they are no indication level matches that job profile.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

Let me say that I am very skeptical that the highest AV level will be here anytime soon. The extent that skill mismatches is a reason for unemployment, or low employment leverage, presumably at the higher automation level the problem will get more severe. Hence as the level of automation increases, the educational training, changes in the organizations and many other institutional training will be going a drastic change. There will be increase in high skilled workers who have more high cognitive skills. The demand for these kinds of peoples will be increasing. There will be drastic decrease of low skilled workers

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

It is only at the last level that you can actually leave the car completely alone, and you don't have to pay attention. So I think that is the major change. The earlier levels of automation will be equipped with driving assistance and other type of features is not a big difference of skill mismatch in driving current automated level of vehicles.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

To the extent that is a problem it's a short term problem. Upto a five years or decade this problem might persist. Business cycle frequency would be longer. Over long term period, people will also be reacting on type of education to be attained or get updated along with the overall technology advancement. University and educational institutions will also be reacting on what type of degree to be included in the curriculum and more practically oriented education attracts will also react of often they relatively act much faster. As the questions posed are assumed that public will be readily accepting the AVs, then only employment will kick in. So, skill mismatch is less of a problem in the long term.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Definitely the taxi drivers, and the truck drivers and the delivery workers will try to oppose the introduction of AVs. But, the delivery drivers are unfortunately are not organized. But I can imagine that the truck drivers are and the taxi drivers are, so they will be able to express their values in the public. They will be pointing out their services besides driving and may be every other thing to halt this development.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

As I said before there is only so much educational institution can do. It is much more important to industrial policy to change the types of jobs that the industry and service sectors will demand. I think, like the labor market policies will be helping to activate people by giving them new trainings or incentivize the public to switch to new domain of industry. You know some new trainings and otherwise device them to take on a new switch industries to new job. So, that's the meta of sort of international strategy for innovation and industrial development. Such a strategy will notify which type of skills and jobs are in demand. The AV unemployment problem is not large in Netherlands. It's a meta of having a good growing economy that is striving and also low productivity kind of jobs are generated. Most important and powerful of all, will be the growth policies, innovation policies, industrial policies and many more will help in determination of which jobs and which skills will be in demand.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

The employers always want to outsource their education to the state and not pay for themselves. But to the extent that they can actually educate their own employees, they can take certain measures to minimize this skill mismatch. In the past many companies were active in many fields and different domains. They work in agglomerates may be operating in different domains and then it was often easier to find a job somewhere else. May be today, if they focus on core businesses, they have less opportunities to switch company elsewhere. The moves by certain companies like outsourcing their services that they usually do can be minimized and

done in house thus helping low skilled worker. For example, many companies don't employ their own cleaning workers anymore; they just employ external workers to do that. So, in the past, if you had no use of particular employee, you could always put them maybe be the superintendent, or the security guy in front of the building or cleaning, training, where you could always maybe find a job for this person. Now, with all kinds of jobs being outsourced, this is more difficult. So, if they do these jobs in house itself, then it can also be one of the methods for not firing low skilled workers.

3.3 Interview transcript (Code ICC)

Interview code: ICC

Interview medium: Telephonic interview

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

I think it is one of the main factors rom all the research that I've read in economics and lot of research by Acemoglu and Autor focuses more about skills and different tasks. In the traditional economic model we have two factors of productions i.e. labor and capital. So, this economic research introduced the idea of a task. So instead of just having labor capital, you have tasks that this labor capital has to perform. And let's say an automation of these tasks will shift these tasks from labor to capital. But if you want to stay the same, the labor needs to get some new tasks or you need to also the new automation is to be creating some tasks for labor. And because automation, in many cases, happens faster than the degree to which we can create tasks. And automation could also create tasks, that's different thing. But the point is that even if automation creates these tasks, labors in many cases are not ready to perform these tasks. And that is what I understand from what is skill mismatch. There are two behaviors here. The one is to what extent the automation going to lead to the creation of these new tasks. It might not even create new tasks for labor, like let's make it specific to AVs, you have a self-driving vehicle. All companies fire everybody, because they went for automation, and they just saved money like this. But you could also think that, maybe they do not want to fire everyone. And, of course, this relates to the context of every country. So in the in the Netherlands it would not be easy because of the situational settings we have. And then maybe companies think that they actually want to create a new task for this labor. I want to improve my service. And I'll have like a host in every bus that welcomes people, so you just add human interaction or whatever, but the bus is being driven by itself. Now, the question is, that's a simple example, if you don't have great skills for that, or let's say people would have these skills, but I can think of many other examples where people would need a lot of extra, let's say, education and a lot of extra training in order to perform the new task, and that's where the skill mismatch would come from. So that's why I think it is a factor because it is kind of by default, training the people and the creation of tasks, or the creation task is much faster than the training but you need to get educate these people.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

That's a definite yes. For this question I can also use a bit of result that we have quantified, which we still do not really understand, for example, why in certain countries or why certain industries we see more tasks being created, rather than jobs being lost. But we do see huge differences between countries and also within the country between different industries. Intuitively I think it has to do with core composition of industries in the country. So considering the case in The Netherlands, it is quite prepared for things like that, the labor force on an

average is bit more high skilled and the industries are more of high end. In Netherlands on an average the people are educated, more skilled. Definitely these things will be impacting the skill mismatch. Netherlands position itself in top five. The practical education is something that's really important here because we're talking about jobs. You know that, these jobs that are at the highest risk of being automated, especially when you're talking about, self-driving vehicles. These are practical jobs and some countries do not have these types of education or like the systems to train their people. In that aspect Netherlands is quite ahead in education system. Some of the universities or educational institutions are more oriented towards practical and scientific research and apply them in the real world. And there are other educational institutions like MBO which is solely dedicated to practical education where you will be trained to specific jobs. These institutions are flexible with training the people, and they have option to get trained irrespective of the background of the studies.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

For instance all traditional industries, that is highly into R&D intensive industries that invested a lot in innovation and industries that have to do with ICT. These industries in the results that we have calculated also for the Netherlands, they seem to not be losing a lot of jobs as a result of automation, but actually creating new tasks for labor. It's not dramatic in the Netherlands in terms of losing jobs, but it's let's say the balance could be negative, which means that you lose a bit more jobs compared to how many tasks you create for labor. For example, transporting people or driving job will be more into traditional job. Logistics industry as in the port of Rotterdam might be affected.

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

So I think that the biggest problem for the Netherlands would be the skills being diminished in the driving or trucking industry and taxi sector. So along with this, skills that need physical effort and the average skills at the moment will not be completely replaced by the computers or AVs. There will be increase in complex information processing and interpretation skills. Due to rise in automation i.e. computer knowledge there will be increase in training and teaching institution. There will be decrease in certain type of driving skills. But, there will be increase other type of monitoring driving skills. All type of work cannot be replaced by the computers, that’s the research which is going on at the moment and I do not have any result yet at the moment. That's exactly what we're trying to identify now, whether industries or jobs that have these cognitive skills, whether these suffer less from automation. And it seems if that is the case, definitely it would be the jobs that do not have that element so much that will be affected at least at the moment with the current automation that we have. On the other hand if do replace the labor their physical task and what left is that the company will be in position to introduce new task for labor, which will be giving rise to cognitive skills which cannot be replaced by the current level of automation we have.

Q5: Will it be similar or different for each labor workforce?

So, depending on the industry, you have a certain set of skills that are important. And the more of these cognitive skills you have, the less I think these industries will be affected at the moment by the current level of automation. If I go back to the five elements of skill mismatch, skill shortage or skills obsolescence, these are different between different industries. So for example, some industries will not have the issue with the skills that were previously used in the job and now no longer required or the skills diminishing with time. The skills having all these elements cannot be automized at the moment or automized very well. So, like cognitive skills. And while other industries that use a lot of the physical skills will have a bigger issue, because the skills can now be fully deteriorated or also can be fully replaced by automation

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

In general I do not think this will be a huge problem in the Netherlands. The elements from the policy perspective they do exist here you do have quite a flexible labor market. You do have flexible education system. The government seems to be paying attention to these developments and protect the labor force. So, institutionally, the setting is pretty good, I think for the introduction of these kinds of technologies. Also, research on which are the countries that are ready for AVs, and The Netherlands is at one of the top position. I think that the adjustments, would be much easier here.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

No, it's definitely different for every level. And, for example, if you're introducing it step by step if you are going from level one to level two and then gradually to level five. With even some training I even think that the skill mismatch will not be even such big issue if you are gradually introducing the automated vehicle. I think it could also be a solution to the skill mismatch if we combine this with some training.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

I agree that it is a short term problem; it is definitely not a long term problem. You can deal with that. We've dealt with this in the past with different types of automation. For example, you know, we used to have horses and the horses were out of the labor force and we have the cars to commute around. It can take some time to get adapted widely. So if you would just immediately introduce automation, you make it a short term problem to deal with, it's a shock to the labor market. And the labor market is slow and cannot adjust very fast. And if you do it step by step the problem can be minimized. It is also not a long term problem, because with training and other incentives, you can steer the labor market where you want it to be. I think that this middle solution where you do it step by step is a way for you to not suffer so much

from a skill mismatch, if you grant people to move to new types of jobs where they do not have the problem of their skills being deteriorated.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Definitely they would not welcome it. But because we're talking about the Netherlands, I don't really expect some mass resistance. And well this has to do with a little bit of context here in the country, like in The Netherlands we have quite strong unions, but the unions are always in quite some good relationships with the representatives of the employers and also the government. If anything, the problem with the Netherlands will be that these all these different stakeholders will be talking and talking for too long, like they do sometimes until they find a solution. But I do not accept expect resistance.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

We talk a lot about market failure. But it's basically what the market fails to deliver. And that means that you require government intervention or like regulating the market corrects for these market failures. Like, for instance, education has a lot of positive externalities, good for people to get education. If you just leave it to the free market, let's say the free market only cares about profits, profit maximization; you will get too little education. So as the government you need to subsidize this expansion. In this in this case, there's also a little bit of a market failure in a sense that companies themselves will not necessarily have the incentives to do something about the skills mismatch. So, like to train their people if it’s too cheap for them to completely replace them. As a government you support certain groups of people with subsidized training and you do it as a government and you do not wait for the companies to deal with that. Training people to address the skill mismatch also fall under education and is something that companies would be providing by themselves. Modernize your education system and keep it up to date. But if we get a lot of automation, we need to protect labor, maybe in the way by starting taxing capital, because then otherwise companies will have too much incentive to automate everything. This is not necessarily needed.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Voluntarily providing the training to the employees and creating new task for the employees after the AVs are introduced. If the physical part of the job or the task is gone, as a firm they should be focusing on the cognitive part, so train them, give them with those skills and give them the new tasks to do those skills.

3.4 Interview transcript (Code ICD)

Interview code: ICD

Interview medium: By mail

Q1. To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

Well, I would say it is a factor, but perhaps not the main factor. The introduction of AVs will happen gradually. What is important, the demand for transport will probably increase if there will be AVs so there will always be new jobs. We can already see this happen in delivery services, some of which use electric vehicles with automation features. These jobs will require new skills, but a skill mismatch, perhaps not immediately so.

Q2. Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I would say that a major factor is the quality of the roads in different countries. This means that automation may be feasible on some roads but not on others. This will be difficult for cross-country road transport. This, in turn, will require new skills about rules and procedures (see my aviation remark above). I would not say it is a skill 'mismatch' as a temporary problem; it is more like that some people will not be able to learn the new skills at all, which is a problem for society as a whole (inequality). Road transport will become more of a planning/managing job.

Q3. Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

The impact of AVs can theoretically be huge. This is broad ranging from city design to logistics. These factors are described in various research papers. I would argue that with platooning or other automated driving systems, in the long term, there will be a reduction of demand and job loss in the sector. Of course, new types of jobs will come in return

Q4. Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

I think that skill mismatch is not the biggest concern as AVs will be introduced gradually (perhaps multiple decades) so workers will be able to adjust to gradual changes. What could be a concern is growing inequality in society, where, in the long term, jobs will become more, and more tech (programming. procedures) and less manual control. A large part of society may not be able to get such jobs.

Q5. Why is it similar or different for each labor workforce?

More generally, I think that skill shortage will be a concern in road transport (e.g., trucks) as special software skills and procedural skills may be needed in the operation of automated trucks (cf. airline pilots). Think of challenges in docking and platooning. At the same time, the drivers will still need to be able to drive manually, which is a skill in itself. Hence, I think the

demands on drivers will increase, causing some under education and under qualification. For example, one may need at least a BSc degree for operating an automated truck. Quite similarly, the fleet managers will face problems. They will need to manage more complex logistics situations, e.g., scheduling trips of automated trucks. The consequence will be that lowly educated truck drivers may not be employable anymore, in e.g., 20 years' time. This is speculative, but at least training will be needed to keep up with developments. Having said that, manual skills will remain relevant in many other walks of life

Q6. How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

Let's assume there is a skill mismatch, my concern could be that some people will not be able to get a job at all after completing school (within the same transport domain).

Q7. Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

It for sure depends on the level of automation. For example, if we have level 5 automation, then a human driver is technically not needed anymore at all. If we talk about level 3 or level 4 automation, we need a computer expert on-board.

Q8. To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

Mostly, due to the long term that is growing inequality in the society. The actual problem for individual truck drivers may be small because AVs are introduced gradually.

Q9. Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Probably yes, to some extent. There may be a resistance of people losing their jobs. On the other hand, people are now used to being flexible (as compared to the past when the cotton machine was introduced)

Q10. How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Government policies could accelerate or decelerate the introduction of AVs. We can think about rules for technological innovation. We can also think about how/where AVs are introduced. Driver training and testing will also need innovation (e.g. license for operating an AV)

Q11. Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Employers have a responsibility for their employees. People can be assigned to different types of jobs within the company or receive internal training about how to operate the AV. This will be possible in the short term provided that the changes are small and not too disruptive.

3.5 Interview transcript (Code ICE)

Interview code: ICE

Interview medium: By mail

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

On the short term: I agree. Some drivers will become unemployed, and it is not clear if their skills match the job vacancies, probably not. On the longer term this mismatch will become less important

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

The share of employment in each category of employment differs per country, so the effects could be similar in main lines, but not expressed in quantitative terms. This relates mainly to the share of professional drivers. For the automotive sector the differences are way larger. Car producing countries will be affected more, especially in case of shared AVs.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Effects include: (1) fewer professional drivers, (2) more jobs in creating the AV technologies and services, (3) fewer jobs in the medical sector and care for disabled, due to less accidents, (4) due to monetary savings that people will spend in another way: more jobs in the wider economy

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

Fewer drivers and those do probably not have the skills for many job vacancies. (2) I do not expect many difficult to fulfill job vacancies in the AV sector. (3) Fewer jobs in this sector, but the demand are increasing because of aging, and there might be a lack of people in this sector anyway, so fewer jobs because of safer AVs reduce the mismatch. Skill mismatches should primarily been seen at the across-industry level (full labor force, preferably). Society needs fewer drivers, of course. Some can be employed in the same company, the same sector, or elsewhere in society, especially in jobs that do not need specific skills, or skills that can easily be learned. For example, maybe a former bus driver can be a service provider on the bus, at the same company or a service provider on trains or at an airport or can be trained to become a painter. In other words: skill shortage and skill gaps do exist, but can be overcome. But those people cannot do the high tech jobs related to AVs. I am not worried about people in the medical sector, because the autonomous trend is an increase anyway, and if there would be fewer accidents due to AVs, that increase will be a little less. All kinds of mismatches can occur, but come probably quiet gradually, so not a major problem. And realize that society is always changing continuously, also due to changes in expenditures of people.

Q5: Why is it similar or different for each labor workforce?

Drivers in public transport can probably relatively easily be employed in the public transport sector, for example as service providers. For truck drivers this will be more difficult, they probably need to be employed elsewhere in society. Medical staff, especially the more practical staff, can be employed elsewhere in society to fulfill jobs in which they have to take care of other people. Such as places were very old people live. The people needed to develop high tech are completely other people than those who lose their jobs due to AVs.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

We might have professional drivers that become unemployed. The increase in jobs in other sectors will go relatively smoothly, because of the heterogeneity in goods and services that people might consume more.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

Level 5 will be the main changes, because then professional drivers are not needed anymore.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

According to me it will be a short term problem. As in most cases due to structural changes in the economy.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Yes, the unions of professional drivers will protest against AVs because they lose their jobs.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Educate fewer professional truck drivers and maybe also other professional drivers. Education programs to teach people who become unemployed new skills.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Transport companies: hardly options. Companies in the AV sector: train and educate people themselves, or pay for it via commercial training institutes

3.6 Interview transcript (Code ICF)

Interview code: ICF

Interview medium: By mail

1. To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

We already have a substantiated problem of training within manufacturing, and other industries are even less "digital-affine". An interesting source for this could be: "World Economic Forum. (2018). The future of jobs report 2018. Geneva: World Economic Forum."

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I agree that there will be differences, due to the different "digital-affinities" of the different countries. I can mainly compare Germany and the Netherlands and would say, that the Netherlands are more likely to adopt new technologies quicker, due to the overall mentality. Small countries (like the Netherlands) need to look around on other "best practices", whereas larger countries (for example France, Germany) will rather remain on a "it was always good what we did, this is why we will continue to do this" mentality.

Q3. Do you see other factors affecting the employment after AVs are introduced? Which factors? And why?

I think the skill mismatch is already a result out of different factors (like "digital affinity", but also for example the possibilities of a countries' economy). I am not convinced that AV (or automation in general) will reduce jobs – it will be rather a shift in jobs. This needs to be specifically analyzed within a country and will also differ between different sectors. This is why I think that the skill mismatching will be the crucial factor of employment – if a country is able to produce AVs for example, this will generate jobs.

Q4. Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

I think this heavily depends on the sector and is not easy to analyze. There will be AV-application sectors like mainly agriculture, logistics and intra-logistics, evtl. public transport – I would say each will have different answers on the above question. And there is the AV-producing industry like mainly car manufacturing and the connected supply chains. This is hard to predict, because it is the question whether the existing OEMs (and their supply chains) are able to stay in control.

Q5. Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

I think the role of the human who is able to supervise the self-steered fleet is going to change which will be in need of higher educational skills. According to me this will be leading to more

demand of a particular skill but there is shortage of the same. In agriculture, logistics industry there will be skill diminishing where certain people will be losing their jobs.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

It will be limited for the highly AVs. As we see a lot of transition of skill set and education in the lower of automation of AVs. And it will be taking lot of time for highest level of automation of AVs coming on road; this problem will be very minimal.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

No of course, it will be changing for each level. As I already said there will be long transition between the levels of automation, there will be much of problem with under education and under qualification. There will be problem with diminishing of certain skills but eventually the labors under these skills will be retrained and help them with reeducation programs to cope up with the new technology

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

It will be definitely a short term problem; it is something that can be compensated through considering with broadening the education institution.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Yes, the unions of professional drivers will be resisting. Current there are few resistance towards truck platooning. Automated trains is also one of it which caused opposition from labor unions

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Policies regarding retraining are the most important ones. Manual labors needs reskilling them and helping them to find relevant jobs. Retraining will be addressing most of the skill mismatch problems.

Q11. Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Including the labor union into these changes. An example out of the supply chain: There will be highly different parts required, if you consider electric driven autonomous cars (future scenario) and “current” ones. I am involved in some of these discussions in Germany currently, and a supplier for example decided to offshore the production of the future scenario parts – because at the moment there are more “current situation” parts. If these discussions are widely made with a very short-sighted mind, this will affect the labor market.

3.7 Interview transcript (Code ICG)

Interview code: G

Interview medium: Skype interview

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

I would not call it skill mismatch; I would call it skill development. And I think the skill development is required for introduction of automated vehicle. So, you will have new skills in, in R&D and the production of the vehicle. So, that will be new types of skills this is happening all along already. So, you see that in any industry a development has already taken place from classical mechanical engineers to also Information Science and data science. So, that is already occurring, I think in the operation of the vehicles that will be new training required for the drivers. So, for instance, drivers now, driving with autopilot is not part of your driving examination. But in the future, the driving without autopilot will be part of your examination. But this is a legal process and to introduce that into the examinations and you need to have some European standardization for that. And then at the higher levels when level three or level four, then you need to have also a back office that is monitoring the operation of the vehicles because the driver is not supposed to be responsible anymore. So you need to have people in the back office there. And for instance, you can compare it also with automated metros, automated factory systems. So, they all have a system where they have high levels of automation, but they have people monitoring what it does and handling also the exceptions and doing interventions if that's needed. It's not that you first introduce a piece and then consider the skill match. It happens at the same time. It's an incremental process. So you would never introduce public transport systems without training drivers. So we're not saying we're first going to introduce buses and then after the introduction of the buses, we're going to see if we have drivers. So you know that if you are introducing buses that do need drivers, you do need mechanics, and you do need people for the fleet operation and management. So it doesn't work that you first introduce the system and then consider the mismatch.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

Yes, definitely it will be differing from country to country. In terms of the people that are driving the vehicles are now also the complete responsible for monitoring and I think you need to have a high safety culture in different countries. So I expect that the countries that are leading in traffic safety already, that they will be also the first type of countries with a high level of responsibility or drivers. I think that's the first part for. So, for instance, Scandinavia is high. UK is high; the Netherlands is also in that group. And other countries like USA they will put less emphasis on the driver training, and so I expect more problems there, because they are also quick in introducing the system. When it comes to countries like Japan they are favorable. Countries in southern Europe have less good traffic safety package. So I think there it's different. I think China will be developing fast probably India as well. China is also very quick in

development of the motorways at very radical enforcement of people not abiding with rules on the motorways. So I think in terms of workforce countries with large percentage, so it will be quite skilled labor doesn't mean that you need to have a PhD, but people currently doing normal skilled jobs like bus drivers and taxi drivers. They can also be active in monitoring and operating these systems. So you need to have a good skilled workforce in the country. And typically, we have that in Western Europe in the US or in China.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Let me say that there has been so concerned with truck drivers. But, but we have way too little truck drivers, that there is a huge demand for truck drivers. So, and it could even be that our economy is suffering from the lack of truck drivers. Don't think the truck industry could benefit from automation. And truck drivers could also benefits from automation and it could make their job easier. And things like truck platooning; we'll still involve the drivers, especially in the first stages. So I'm looking at the first stage is coming in the next 20 years, I think these are the most interesting ones. We'll make the life of drivers easier. I talked to some of those truck drivers doing truck automation, they really liked it because normally now their job is extremely boring. Now they can work with new fancy technology, which also allows them with other people and you know, these are very curious guys. They're very interested in this new technology okay. So they are embracing it and it will not quickly replace them. Along with this, I think one industry is going to change is the business model of the automotive industry and they are selling cars to private people. And I think the privates' possession of a car or private ownership of a car will disappear. It will be like if you are getting your own car, it will be based on the subscription. The advantage of this will be that the car will be part of the financial service or lease service and also that the company retains full control of all the software and information on the vehicle. It will also be connected to agreements about information, information about you, about status of the vehicle and information about trips that you make.

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

Well, if you have the highest level of automation, then I don't see that you have any old forms of mobility still effective, or still valid. So I don't think there's any room for normal cars anymore. Few of the tasks such as dynamic tasks are done by the system; the fallback is done by the system. But what happens if a system comes to a standstill? Because the system can't cope with the conditions, human operator needs to intervene. So this is what you see in all level four systems. And actually, there have been very little real level four systems because in most of these cases, a supervisor is still on board to system. If you look at the Waymo vehicles, there are still two supervisors on board; to monitor one vehicle and these are highly skilled people. So, in terms of skills these are the people with a PhD degree in machine learning or whatever that are supervising the system. So in that sense, the complexity of the operation of the system needs to come down considerably. Otherwise, we need people with a PhD in monitoring the system and you cannot come to full scale deployment. There will be increase in

higher cognitive skills and it will be the most important among the other type of skills. Apart from these we should not be underestimating the emotional and social skills.

Q5: Will it be similar or different for each labor workforce?

Yes, it will be changing in each type of the labor workforce. I think the highest change will at the end users. Okay. So, But changes are needed in all the categories but it's very decisive the extent to which an end user is able to operate in a new generation of vehicles.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

Considering the level four automation systems there is still a supervision needed. Level four is for a certain operational design domain. And this operational design domain limits level four functionality and outside that system does not support. So, that will be operated by geo fenced operation. And also again human operators will need to be involved in deciding about where and when automated driving is possible. For instance, if an accident happens if communication breaks down, if there are slippery roads, then the system may not function as intended. Somebody needs to detect that intervene and give new instructions to the vehicles, whether they're able to drive at all or human driver would need to take over and then in terms of skills, you need to also have a human driver to be able to understand those situations and take over control. There is a need for skill development, especially in the higher cognitive skills. And this already occurs in all levels of automation.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

Yes, there will be differences in each levels and it will complicated from level three and level four, because there are many transitions between the human and the vehicle. So, I think any system that is now closer to the market that has some elements of AI it will still have a driver that will have to monitor. So, if you look at level two systems, level two systems are systems where a driver is doing the monitoring. So, the OEDR is done by the driver or the fallback is done by the driver, and this means that the driver needs to develop these new skills. Level one, level two; there is project studying level three level at level four. So it's already occurring and we're learning and which places automation is possible and which places is still problem

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

It's a fundamental aspect. If we change the interaction between humans and their vehicles it's both a short term and a long term problem because you need to start working on it now already to make the changes that we need.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

I don't expect a lot of resistance from them. So it's going to create many new jobs and it will be a gradual process in which drivers and their current jobs will still remain to be there and the

new generation and also the low skilled workers will be able to work with our system. So I think already in the schools and Institute's for education, this is already going on. So, I don't think I'm not expecting a big opposition.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Very little, I think you need much more active training and awareness. And marketing does not help marketing is aimed to sell the systems and selling the systems is no guarantee for the safe use of the system. So you need to have a much stronger emphasis on training and education.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

The measures that as an employer can take is to create awareness of the new technologies that are coming and to train their employees for the future requirements of these new technologies. It's like any technological innovation occurring throughout our society. So, technical progress is occurring everywhere. And if you don't pay attention, some jobs get outdated. So I think companies need to monitor at and continuously change their education and training programs for these products and services.

3.8 Interview transcript (Code ICH)

Interview code: H

Interview medium: Skype interview

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

I think it will be one of the factor and not the main factor, but it's a temporary thing that will happen in the beginning that happens to any automated industry. So it's a temporary thing because if you're doing stuff that a computer can do better than it's either thing that we didn't add value, anyhow. It's a boring kind of repetitive jobs that we should not be sad about losing the same.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I think there will be a different set of skill mismatches compared to highest automated countries probably will. The more expensive your workforce is, the more interesting is the job more to be automated and the least expensive or less or the biggest problem will be there in the countries that will have a lower paid wage force because there driving a truck is still interesting alternative. In the higher wage countries there's plenty of work for truck drivers also make some good money.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Again if there's a question that will happen, of course we are talking about truck and lorry industry along with that there's some more workforces as well like insurance, services like police authorities. As the traffic congestion will be lowered and the job of the traffic police will be minimized. I think there's another area, for instance, public transport, all this other kind of stuff. The makers of vehicles produce the fetal stable transport will have harder time to sell more cars. So, that will be affected as well and there will be some positive impact.

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

I think it's a general thing of what you see on automation industry that you see a shift from repetitive covering inside the line kind of jobs. So applying rules and binding regulations, stuff towards that's about covering outside the lines. Definitely do creative stuff. So I think if you, in general, on the high level, if you see the distribution between the jobs that robots do in the jobs that we still do in the future. I think that the robots will do the jobs going inside the lines following the rules and regulations. So we should never allow these robots to go outside the lines because that's a dangerous no go area to my point of view, that would quickly increase the speed towards human extinction to put it a little bit lucky. There will be increase in emotional skills and creative skills. So just to give my two dimensional approach to within the lines and

colors without the lines, I think the emotional and the creative stuff is coloring outside the lines in a repetitive machine like jobs are coloring inside the line. So that's my point of view would be distribution.

Q5: Will it be similar or different for each labor workforce?

I think the general rule is that when a certain jobs require a total conditioned world, in which you can just apply rules and things will run. If you go for an unconditional, world In condition word like traffic, everyday traffic and also how we relate in a society, which is not condition, which is not all, by the rule. I think it just needs us to apply to different situations that are not conditioned. Robots work well in the condition environment. We tend to work in an unconditioned environment, which normally performs better than the conditioned world. Well, if you look at traffic specifically Indian traffic, for instance, it's totally following different rules than the official rules. But the performance, apart from some accidents, but the performance of itself, therefore, is so much higher than what if everybody would stick to the rules, and that you do not want to shift to a conditional world where the robots will feel better. So why it's not similar or different from each labor workforce is depending on how conditioned you can organize an environment in order for a system to work, in certain labor workforce where you're working in a very conditioned group, that's where the impact of robots will be much bigger than working in an unconditioned environment.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

I think we're talking about a situation of autonomous cars of level five, that might not occur for the next decades if ever. But, given the fact that it would happen, skill mismatch would not be major threat for the employment. It is also very similar to any automation that we have foreseen. But it always reminds me on Milton Keynes, the big economists, that that came to China and he saw a lot of Chinese people digging holes I'm working on Roads construction using a shovel. So there were just individually just replacing sand. And that he asked to the Chinese government and he asked, why don't you use bulldozers? They say, but this way, much more people are employed. So we keep people busy. And then Milton says that a good idea for you, why not give them spoons instead of a shovel? Because then you can even apply much more people to it. That's actually the essence. You should never invest in these kinds of things just for the matter of having work.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

Of course it will be changing for every level of AVs. Main thing is, for level one and two it's still the person who's responsible for everything that happens. For level three, you have the part time responsibility with very difficult shift moment. So there's still a huge responsibility with the drivers. Same with the level four the involvement is minimal compared to level three. And for level five you need no assistance, but certain monitoring skills are required.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

So after that we invented electricity. We didn't need candle lighters anymore. And that was a problem because we had a lot of people that were very good able to latch on to light candles on the street lights, etc. Put them off in the morning. But I think they found out a job in due course. With each automation, it's a short term problem. You always have objection to people that lose their jobs. In due course, they will find better jobs that add more value to the community than what they're doing.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Yes, definitely there will be resistance. There will always be luddites who thinks machines that are invented are unnecessary. You will always get lot of objections for new technologies emerging in the society. For example if you consider the invention of light bulb, this dominated the candle industry. It’s a temporary thing that you always see.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Yeah, like retrain people, etc., is something that's always been done when there is kind of big shifts in the economy. So yes, you should retrain people, but it has a limit. You cannot expect a former truck driver to become a software developer, although some will be a successful software developer. But an average truck driver is not the prototype of a good software developer. So there are limitations to that one. But there will be still a lot of jobs in between and we still will need a workforce. The thing is that the countries that have the highest level of automation, in practice always have the lowest grade of unemployment, which is a paradox thing. But normally the more automation you see, the lower the unemployment it is. Hence there will be jobs.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

I think they should have a little bit more of longer term vision of where it's heading. On the short term, it's always a disaster for an industry when something is automated on the long term, it will lead to a better situation and people adding more value to the society than what they did in the former job. I think half of the jobs that we do are not really contributing anything to the society. So, although these people might be happy with it or happier if they really contribute something to society and they will feel it somehow. So, I think we should not be too afraid and all these kind of unions etc, they should have a longer term view that things will get better

3.9 Interview transcript (Code ICI)

Interview code: ICI

Interview medium: Face to face

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

Yeah, I think there will be a skill mismatch that is something we need to consider. But it may even be that automation addresses a skill mismatch, which we have today. And that is today, it is challenging for the bus companies and the truck companies to find drivers. That means we may be scared of losing those jobs. But in fact the jobs that automation will replace are at the moment is hard to fulfill. That is because they are relatively are not well paid and are not of high esteem and these jobs can be seen as boring, although some people really like to drive a truck in particular, but for buses there is issues of lower back pain of drivers not well able to do drive until 65-67 or longer. So, automation will actually resolve one of those problems.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

The problem which I mentioned of recruiting drivers is only a problem as far as I know in high income countries. And that means studies in the countries where a majority of the population is rich; it may not be as attractive to be the truck or bus driver. And of course, there are still many countries where labor is cheap and easy to obtain***.***

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

All the professional drivers will be affected. Also those who commute a lot will be affected because their commute time may become either work time or leisure time. And especially for the commuters I think they will be winners and they will benefit from it. But there is of course also a risk and it's not a risk so much for the labor but more for traffic system that if the travel time becomes enjoyable and if we also resolve congestion at the same time by automating traffic better that may lead to even more traffic. And instead of professional drivers there will be control rooms. I think that for especially also for social security for public transport a control room will be important. Of course the public transport already has control rooms, but these will become more noticeable to the users of the vehicles which will create some additional jobs but of course, it will create fewer jobs than the jobs which have been replaced. Insurance companies have been afraid that automation will disrupt their market. If collisions will become rare, their turnover will be minimized and that's not what we see happening today is actually with some of the level two automated cars through is anecdotal evidence that there is more damage, not necessarily severe accidents buy more minor accidents, more parking damage for instance and traffic jam. But on the long term of expectation is of course that traffic will be safer and the airport for their business will shrink. It will also change because their primary customer will no longer be the individual user. More to the carmaker because the if you buy the

automated car you would rather have it insured in such a way that all liability whether it was the car maker who is liable for an accident or you misusing the car, those questions are taken away from you. And that's what I hear from car makers and insurance companies that the car will come the automated car will come all risk insured your liability will be very limited. Of course if you own purpose create an accident you will be liable

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

The industry will be in more need for artificial intelligence, electronics, computer systems, but also Human Factors, because as long as the human has a role as passenger we have to understand whether people trust the automated car and if humans are interacting with automated cars as pedestrians, we also need to make sure that that interaction is intuitive and accepted. We may be actually scared for multiple willing to share the robot automated vehicles, they behave in a way which we don't like. So, more need for human factors. So the design of the automated car will not be simple. In the driverless public transport or the driverless taxi, your level of trust needs to be even higher, you need to fully trust on the automation because you will have no brake pedal or you will have no steer to take back control. And in that trust will be positive if there is a control room, which you can still ask whether they can intervene with vehicle driving task, but there will also be challenges of social interaction if you share an automated bus with others and there is no professional driver on board this control room and the physical presence of the control room with like an interface okay is expected to help the acceptance of automated.

Q5: Will it be similar or different for each labor workforce?

Of course the professional drivers they will have to learn to supervise to automation it will be the case for truck drivers especially if they drive in platoons. There will be probably professional driver in the lead vehicle with responsible for the entire platoon will become more challenging task. It is still the question which will happen truck driver in the other vehicles because they may be allowed to rest or do office tasks. But it is debatable whether if you have platoons of like five trucks, whether there will be sufficient work to do for those four truck drivers in the following vehicle, what should they do? Can they sleep or not that that's also uncertain.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

It will not be major affect on the highest level of automation of AVs, if the AVs are introduced in the gradual manner, so that the labor market is not in a shock when the highest automation level fo AVs are intrdoced to the society. If it is in a gradual manner the educational institution will be upgrading themselves eventually with the trend and there will not be a much of difference with the skills with respect to the levels.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

We are in good contact with the CBR which is the Dutch organization responsible for training, driver licensing. And they gradually include these level two automation and things like navigation systems and their curriculum. Reaction time was increased with automation, which means that the mental workload of monitoring automated driving is higher than the mental workload of manual drive. For level two the driver will need drivers will need some extra training to use it safely. And that's not a massive amount of training.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

I think it will be a short term problem. And also since the initial estimates of automated driving were hugely optimistic and it will not change overnight like we work on a lot of projects with driverless buses, but these will only very gradually replaces the normal versus okay we should not worry about there will be a mismatch but it will not be a huge problem.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

I think the professional drivers will resist. There happened to be resistance for driverless trains. There will be resistance that the taxi drivers whose jobs will be taken by automated taxis will complain and will erase some concerns, but in the end for society, it will be even a solution rather than a new problem caused by automation.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

The training of new drivers will be handled by the CBR. Carmakers needs expertise in artificial intelligence or human factors.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Employers should retrain their employees and get updated with current technologies. Should br motivating them to learn new skills.

3.10 Interview transcript (Code ICJ)

Interview code: ICJ

Interview medium: Face to face

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

Netherlands have shown some ability to adapt to new trends, could be an issue in the future. There are a lot of uneducated people who need jobs. At the same time the productivity has been increasing, so you can distribute the income from the population. Okay, so I don't see that as a major thing yet. But you know, we don't have a crystal ball. I don't feel that the Netherlands is the most concerned country or should not be the most concerned country about this. But you have to pay attention because the countries is very organized, very productive, and it can support people who have low skills, has ways of kind of transferring the wealth, the GDPs to those populations. If of course that layered of that population goes too much for what the productivity can support, then you have a problem. I haven't seen this yet, but we never know.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

I think so it differs from country to country, especially low tech. Like I want to say countries that are not well structured and some layers do not support the lower layers of the society. So more unfair countries, this could even be worst they could be very bad. Here lower level can be generalized to lower level income countries. o the lower income level people for example, I'm from Portugal. And the difference between the rich and the poor is increasing. And this has to do with the fact that some part of the population is highly skilled, they find good jobs, they have good salaries, and other people have lower and lower paying jobs. Because there's more and more competition for those low income jobs so to speak, and you can even lower more the salaries. So you have like, kind of a negative reinforcing.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

So think that the winners are definitely the tech guys. Tech people who actually have studied to be engineers, for example, computer science, mechanical engineering, they are for sure are the winners of this domain. But on the other losers are the people who are low skilled and with low education i.e. drivers of taxis and trucks. Software is improving. You need the data scientists and companies that produce software. Companies that test vehicles and manages fleets of vehicles. Fleet companies include for example renting companies, leasing companies and car sharing companies. Here the vehicle is the main asset and they do not need drivers and the drivers actually represent a large cost of their business. People who repair cars okay because the cars become too cumbersome, they are just software, it's not easy to open one of these vehicles and start repairing this is not possible anymore.

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

There could be skills shortages in these tech jobs. There will be skill gap in fleet managing companies. This means I don't need drivers anymore and I need people who can just care about the vehicle. Under education related with the tech companies. There will be no need of some skills which are not required anymore particularly in the case of some of the truck drivers and other professional drivers.

Q5: Will it be similar or different for each labor workforce?

Technology is changing and some are based on the old technology some jobs are based on old technologies. The other jobs are actually about developing the new technology, if you have a job that is just about being experienced with something that exists now and if you are not on the business or on the jobs that are about developing the future then you lose the train, so as to speak and you stay behind. So, for people who are developing software, and also data scientists etc., this is actually the future. Yes, there could be a scenario in the future that this is not needed anymore. But maybe in the scenario that artificial intelligence is so developed, that you don't require so much the human anymore, this could even happen that you have obsolescence in those high tech jobs. But at this moment, what we're seeing is that everything that is happening in society requires this type of skills, to be developed.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

So I think that there will be more people that will have to Study, new skills. Hopefully there will be a way of recycling some skills because you know, some of these tasks that we are mentioning, for example, do diagnosis on vehicles, this kind of work. Today already some of these mechanics in the repair shops are able to do so they had some training. They can learn some skills, and I think this is actually going to happen. That's why I don't see a much of tragedy on the job market at least. There will be a way of adapting of transferring some of these people to these new skills. But again, I don't see a mechanic going to be a top software engineer. And one of these high tech companies that we have here in the Netherlands. I think this is quite hard, but they can still do some tasks and learn some skills.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

I think that every level of automation brings the vehicle becomes more intelligent again becomes more difficult to understand by just the common person. But of course, at the level five and level four, if we have a lot of implementation of level four, in the in the Netherlands, they are going to make the biggest difference because they are the high automation levels. And they don't require so many drivers. If you tell me level four, in some places, it will have to have a driver. Then again, we still have some drivers that can bring softer transition. But level five is the one that brings the biggest changes, but it's still also the one that is not happening so soon. So, it may happen that with the evolution of the levels you have a transition of the market.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

According to me these kinds of changes in society cannot be that short term. But at the same time, I don't see a long term problem. It's a major issue of society and possibly something that the government cannot control somehow, and I feel that this would be unlikely that is not controllable. At the same time I feel that short term if you talk about just four or five years, this type of process does not happen in four for four years, and then it's sold or something. So I would say something that will probably go on to 20 years. And then the job market adapts and the government finds some ways of tackling. This is also not a problem that just the Netherlands is facing. It is many countries, who will be facing at the same time. So I think we can also learn from each other. So, indeed, I hope for something that is more medium.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

Yeah, this is going to really depend on how companies are going to manage this process. There is always resistance. But I think that some countries are better than others in these processes and maybe the Netherlands will not be the worst one. For example, compared to France where these unions are, they just want to maintain their status quo. It also depends on the nature of people, kind of education and the society. I think that there's going to be some resistance but not extreme resistance, but also depends on how the governments and how the companies manage this process.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

For sure that is not something that should go wild and random. This has to be steered. This needs in indeed policies from both the tech side but also from government from the labor market from law, so that we can avoid a clash and that things go smoothly this in this transition. So it is required.

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

The employees have a big role here. They must be concerned, they cannot be selfish, and just think that OK, I'm going to transition to this new reality and I don't care what happens because it is too fast and not to create clash. So, the employers working together with governments, they must understand how to be able to transition some of these people to the new jobs. So, in some cases it will be possible in other cases maybe you have to retire some people or give them other jobs in other places not inside the same company. First, I think you can divide people you can some people can find new jobs inside these the same organization; others have to find in other types of organizations.

3.11 Interview transcript (Code ICK)

Interview code: ICK

Interview medium: Skype interview

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting the employment in the labor workforce?

According to me it is one of the factor that affects the labor market which affects the labor market. There are many other main factors that affects labor market other than skills and tasks. Other factors such as policies influence the labor market in terms of how the introduction of AVs are done, whether if it is in a gradual or disruptive way.

Q2: Is the skill mismatch factor similar in all the countries or will it differs from country to country and why?

Yes, it will be different in each country. So in each country, you have a different structure for the economy as well as the labor market. I think that says there will be a difference in the influence of autonomous vehicles on the labor market. It could be some countries will be still relying on low skilled labor substantially and those will be influencing much more than other countries when AVs are introduced.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

I think the whole freight transport to the logistics industry will be affected. As mobility, taxi drivers will be affected and these will be the losers. It is hard to say who will be winners as it depends really on how this technology is being adopted by the users.

Q4: Which type of skill mismatch would result in the above-mentioned industries due to the introduction of AVs of the highest level of automation?

Let's say in the truck or in the taxis, they are not really drivers anymore, so they need to shift their role from drivers to supervisors, or monitors. And there will be also remote controllers so there are remote control centers. And there will be new job vacancies that they need to be able to supervise remotely the autonomous vehicles. So, these are the skills that I think they are not there yet, but it will be emerging in the coming future.

Q5: Will it be similar or different for each labor workforce?

Yes, it will be different. So driving, as a profession, those will be influenced the most I will say, but indirectly there may be other workforces influenced.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of the highest level of automation?

As I previously said it all depends on how the AVs are introduced to society. If it is in a gradual manner it will not be a major effect on the labor market.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

Certainly, it will not be the same. The drivers are still playing a significant role, but level four, and level five there will be disruptive changes. So, certainly not the same.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be a long term problem?

I think it will be a short term problem. Because at the introduction of these vehicles you would need to adapt some of the professions from labor-intensive work to more knowledge-intensive work. But I think this shift will take some years, but they're not really long term.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

There will be certain resistance from the professional drivers. They are afraid that might be losing their jobs. That's the reason they will be resistant. I think there are three elements, first is the grip on your monitor is that you have a grip on your work that you have certain control over the work you do. And certainly that your grip on the life that you can combine work with the personal life process. So instead, if I look at those credit criteria. There are several possible consequences of the introduction of various levels of automation and I think whether people will be happy with this existence. It depends on how it works out for those three different elements of the competition.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

Establish issued policies that can help to reduce the mismatch, for instance, already training the professional drivers with this lower level of an automation system. And gradually increase their awareness of the usefulness of the system. And maybe training for future professions like supervisors of automation system rather than drivers of vehicles.

Q11: Apart from policies introduced by the government, what are the other measures that employers (firms) could do to mitigate the skill mismatch due to AVs?

I think training can take place at different levels. So the employers can train their employees towards the trend in automation and also in the long term the companies can anticipate these changes and generate plans that they can embrace the technology change. So in that way, they can leverage the utility of the technologies but minimize the negative impact.

Appendix 12: Interview transcript (Code ICL)

Interview code: ICL

Interview medium: Skype interview

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting employment in the labor workforce?

I agree it will be a factor that affects the labor market, but it will not be the main factor. Because there are some specific jobs especially for professional drivers that will be affected by driving, especially level five. For a lower level of automation, there is only partial automation, so the drivers will still be having driving tasks. And besides that, they are needed to be having other skills like how to deal with the automated system.

Q2: Is the skill mismatch factor similar in all the countries or will it differs from country to country and why?

It is quite similar. But there might be differences with respect to how far automation there is already in different countries. So, some employees might already be more used for automated tasks. And in some countries where there's little automation.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

All professional drivers like truck drivers and trucking companies and carriers will be affected. They have to shift to other jobs and reduce cost and they employ fewer people. And even public transport will be affected as there will be an emergence of automated buses and trains to commute from one place to another.

Q4: Which type of skill mismatch would result in the above-mentioned industries due to the introduction of AVs of the highest level of automation?

There will be high chances that the people might be under-qualified to work in a particular domain or under-educated. For examples. The low skilled drivers might be under-qualified for operating AV trucks from his educational background. Ans also his job like driving might get obsolete as the AVs are widely implemented. There will a decrease in social interaction between drivers and passengers and also an increase in high and basic cognitive skills.

Q5: Will it be similar or different for each labor workforce?

It will be with each workforce as the jobs are different in each labor workforce. In the trucking industry, there will be a decrease in skill requirements or even get obsolete due to AVs taking over the job. The drivers who have lost their jobs might be not qualified or educated to take up different jobs available in the labor market. These skill mismatches also depend on the educational background of the employees. Higher skills and education better the opportunity to be employed.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of the highest level of automation?

If the laborers are not educated or qualified for a particular job the laborers will be unemployed. The level of skill mismatch will be high if the AVs are introduced immediately and not giving time for the society to adapt.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

So the required skills will be increasing. So, from the low levels of automation, You still need to be able to drive but you also need to be able to do some other automation along with driving. There will not be a big change in the lower level of automation as there is still a requirement of human interaction with the AVs

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be a long term problem?

It will be a short term problem because I expect that laborers will shift jobs to match their skills. And there will a long period of time to shift to the highest automation of AVs. And It is not that people will be permanently unemployed. They will find a job as time passes and they will also be given an opportunity to get trained to new skills and educated to current trends of technology.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

I expect resistance because it is their jobs that are at stake. I talk to truck drivers or people who know them. As far as I know, many of them are not very worried about self-driving trucks because they know what they do all day and not impossible to automate all their tasks.

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

It will be very helpful if they can facilitate improving the type of education provided at the educational institution. Adjusting the retraining of skills and supporting low skilled workers and enhacing the subsisized training.

Q11: Apart from policies introduced by the government, what are the other measures that employers (firms) could do to mitigate the skill mismatch due to AVs?

Employees should talk to the workers and ask them what they need. What will help them to do the work. And also the type of technological applications and the development of it. What it implies for the type of work to engage in social dialogue and to ask people what they want instead of just dropping it and see how and see what happens. rather common in the Netherlands, to have the social dialogue. But I think as a technology, this can be much improved.

Appendix 13: Interview transcript (Code ICM)

Interview code: ICM

Interview medium: Face to face

Q1: To what extent do you agree that skill mismatch will be one of the main factors affecting employment in the labor workforce?

If there are fully automated vehicles throughout the world and adopted everywhere, then the world will look completely different. So the skill mismatch will be one of the least of worries which affect the labor market.

Q2: Is the skill mismatch factor similar in all the countries or will it differs country to country and why?

On the one hand the poor countries, the average IQ of these countries is lower. So, their type of employment and the kind of jobs they can do will also be on lower IQ. So, for the lower income countries there will be a higher resistance than in the higher income countries. So, I the Skill mismatch factor will then also be higher in the lower income countries.

Q3: Which areas of the labor workforce will be affected as a result of AVs? Who will the winners be and losers are?

Basically the software engineers, it's all software, everyone that can work in terms of software, computers, artificial intelligence, all all that will, we'll be seeing people will have to manage huge online networks of traffic. These will be the winners. And the losers will definitely be the truckers. They drive for living and they don't have to drive for a living anymore

Q4: Which type of skill mismatch would result in the above mentioned industries due to the introduction of AVs of highest level of automation?

I think skill supply will allow for the introduction and development of ordinary people not aware of the other way around. High cognitive skills will be in rise as there will be rise in AI technology for development of AVs. The physical skill be given lesser importance.

Q5: Will it be similar or different for each labor workforce?

It will be differing in each labor workforce. If you consider the passenger transport there will no more driving skills. And in the software industry there will be in need for labors who are expertise in AI and IT skills and thus creating demand.

Q6: How will the skill mismatch factors affect the labor workforce after the introduction of AVs of highest level of automation?

It depends if the AVs are introduced in the gradual manner then the skill mismatch problem will not exist. If there is a direct implementation then there will be increase in un employement and high resistance from the low skilled labors.

Q7: Will it be similar to the introduction of other levels of AVs or will it be changing for every level of AVs?

For the lower level will have the issue of skill mismatch. Ans we already see it happening and there is common need for people that can monitor and supervise might become an issue. Th world evolves based on what we can not the other way around.

Q8: To what extent do you agree that the skill mismatch problem is only a short term problem or will it be long term problem?

If it is a problem at all it will be short term problem. As any trend, the employment problem will be persisting only shorter duration.

Q9: Will there be resistance from workers in traditionally low skilled industry sectors after the introduction of AVs or would they welcome it and why?

I assume that the trucker for instance will have a resistance there. I assume that sector will be the first to introduce fully automated vehicles, as you see here for one public transport will be affected, from then on again, goes the other way around. We can we do it once we do it's not the other way around

Q10: How the implementation of labor market policies will be helpful in reducing skill mismatch due to the introduction of AVs?

I think policies will definitely be helpful. It's what we encounter now as well. The automated buses are not allowed to drive faster than a low speed, they can go faster, but they are not allowed to again hold more people and not allowed due to policies. The can broaden these policies also in terms of having automated vehicles drive without stewards,

Q11: Apart from policies introduced by government, what are the other measures that employers (firm) could do to mitigate the skill mismatch due to AVs?

Retraining and relocation of work for low skilled workers is one of the measures that can be taken by the employers. They can also involve in collaboration with educational institutions to update with the current education systems and required skills