The Rise of the Machines

A study of the Developing Acceptance of Collaborative Robots

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Abstract

The constant increase of complexity within the international business (IB) environment is pushing multinational corporations to find new and innovative ways to remain competitive. Collaborative robots (cobots), defined as robots that can interact safely with humans, are deemed to be one of the solutions to this. However, when a new technology enters markets, it has been shown that there can be hindering factors impacting the acceptance of the technology within societies.

The purpose of this thesis has been to identify possible factors affecting cobot acceptance and provide a more comprehensive overview of these factors than previous studies have accomplished. In addition, the potential influence of a government on cobot acceptance was touched upon as well as the international spread of this technology. The study was based on secondary data, collecting views from previous researchers and publications, users and producers of cobots, and government officials. The gathered data was then grouped and analyzed in accordance to the variables of this study’s conceptual framework: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions and Government Influence. The results illustrate that cobot acceptance can be affected by several factors related to these variables, such as operational gains and ease of adaption.

Keywords: International Business (IB), Collaborative Robots (cobots), Internationalization, Technology Acceptance, Unified Theory of Acceptance and Use of Technology (UTAUT).
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This thesis concludes Jeanette’s 5 years at Handels and Antoine’s 2 years in Gothenburg. Thank you to all that made these years memorable.

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List of Abbreviations

IB: International Business
Cobot: Collaborative Robot
MNC: Multinational Corporations
ICT: Information and Communication Technologies
EU: European Union
EC: European Commission
US: United States
TAM: Technology Acceptance Model
UTAUT: Unified Theory of Acceptance and Use of Technology
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1. Introduction

This chapter will present a broad summary of the current international business environment and introduce the concept of collaborative robots. It will provide the reader with an overview of the concepts that have been used to further build the research. Towards the end of this chapter, the purpose, research question and delimitations of this thesis are presented.

1.1 Background

Over the past years, the international business (IB) environment has become increasingly complex. Both internal factors, such as technologies and products, and external factors, such as customers and political framework, are making it more complex for companies. Moreover, numerous challenges arise from the fact that markets are increasingly dynamic, and consumer behavior more volatile. This is notably seen through the trend of going from mass production to mass customization (Shen et al., 2016). At the same time, labor costs are increasing and it may soon not be efficient to chase cheap labor at an international scale. In regions such as North America and Europe, standard of living is continuing to increase, leading to less and less people being attracted by manufacturing jobs (Brooks, 2014). Collaborative robots (cobots), defined as robots that are inherently safe to work alongside humans in the same work space without barriers, have been argued to provide a promising solution for these future challenges along with many other benefits (Shen et al., 2016; BCG, 2017; Chuan Tan et al., 2010; Michalos et al., 2015).

Collaborative robots are a new type of robot product that is changing the way in which humans work and interact with robots. Industries, such as manufacturing, are witnessing a revolution led by the rise of these robots. Their development has reached a point where they are becoming smarter, faster, cheaper and, most importantly, able to take on tasks that were previously thought to be reserved for humans. By developing human capabilities such as sensing, dexterity, memory and trainability, today’s robots are more and more assigned to jobs such as picking and packaging, testing and inspecting, or even assembling other robots. These newly designed robot capabilities mean that robots are redefining human-machine work relations, where humans and machines can work in proximity, in a highly collaborative
way that was never before possible in manufacturing. Their ability to do more has created new opportunities for these companies (PWC, 2014).

1.2 Problem Discussion

Even though cobots have been suggested to be one solution to some of today’s business challenges, a widespread adoption of this technology has yet to happen (McKinsey Global Institute, 2017; BCG, 2017; Bloss, 2016; Roland Berger, 2016; PWC, 2014; Pew Research Center, 2014; Capgemini Consulting, 2013). Throughout the years, several models and theories have been developed to describe how, why, and at which speed a new technology is adopted and accepted. Some of the most well-known models within this research field can be argued to be Rogers’ (1962) theory of Diffusion of innovations, Davis’ (1989) Technology Acceptance Model (TAM) and Venkatesh et al.’s (2003) Unified Theory of Acceptance and Use of Technology (UTAUT). Research has shown that users’ attitude towards new technology, and also their acceptance of it, have a decisive impact on successful adoption (Venkatesh & Davis, 1996; Davis, 1989). Cobots can be said to be a fairly new technology and as such, it may still face challenges in being accepted as a new product. Technology acceptance is of particular importance as “one factor that predicts successful human-robot interaction is the acceptance of the robot by the human” (Bröhl et al., 2016, p.97). Operators might not, for example, accept cobots as “worthy” coworkers (Coupeté et al., 2016). Thus, the acceptance of cobots by humans can be said to be crucial for the industry’s development. As such, it can in turn be argued that understanding factors that are driving or hindering this acceptance is necessary in order to comprehend the spread of this technology.

Earlier research about cobots has mainly focused on studying practical aspects such as system implementation (Bloss, 2016; Shen et al., 2016; Grahn and Langbeck, 2014; Charalambous, Fletcher and Webb, 2013; Hinds, Roberts and Jones, 2004), safety concerns (De Santis et al., 2008, Bicchi et al., 2008) and application design (Michalos et al., 2015; Faber, Bützler & Schlick, 2015; Chuan Tan et al., 2010). In comparison, little attention has been given to aspects such as acceptance. To be clear, the topic of acceptability has been quite extensively studied in the case of social robots, the same cannot, however, be said about cobots in an industrial setting (Coupeté et al., 2016). Researchers have, nevertheless, started to investigate
some aspects of cobot acceptance, such as people's perception of human-robot collaboration (Kim et al., 2015; Weistroffer et al., 2013) and cobot acceptance (Beer et al., 2017; Bröhl et al., 2016; Nomura, Sverre Syrdal and Dautenhahn, 2015; Strassmair and Taylor, 2014). While research has been done about these aspects of this field, there seems to be a gap in regards to providing a more comprehensive overview of these results.

In his study, Rogers (1962) theorized that different outcomes in the spread of a technology can not only be explained by the characteristics of the technology and adopters, but also by the characteristics of its context. In their research, Fleck and White (1987), showed that the different diffusion patterns of industrial robots were correlated with one’s national context, such as national policies and means of promotion towards the technology. Through the literature review, a second gap was identified in regards to this and cobots. So far, there is a lack of studies covering country and industry characteristics, as well as national policies and means of promotion, in combination with cobot acceptance. In fact, most studies lack any kind of IB perspective (Shen et al., 2016; Bröhl et al., 2016; Bloss, 2016; Faber, Bützler & Schlick, 2015).

As cobots are viewed as one solution to the increasing complexity within the IB environment, the authors believe that it is of importance to provide a more comprehensive study of factors that may be driving or hindering the development of this industry. The need for this was found through an assessment of the above literature, where the importance of acceptance was highlighted, while comparatively little attention has been given to provide an extensive study of this. Another gap was identified in regards to cobots and national contexts, such as national policies and means of promotion. All of which could be argued to have a potential effect on a technology’s acceptance and international spread.

1.3 Purpose and Research Questions

As illustrated in the problem discussion, the acceptance of cobots by humans is vital for a continuous spread of this technology. The purpose of this thesis is, therefore, to provide a more comprehensive overview of factors that might affect the acceptance of cobots. The focus of this study is to examine factors that are driving or hindering the acceptance of this
technology, and in turn, impacting the industry’s development. With this background in mind, the following research question has been formulated in order to lead the direction of this study:

What main factors can be said to affect the acceptance of cobots as a new technology?

Due to the broad range of this question, the authors would like to once again highlight that the aim of this thesis is to provide a more comprehensive overview of factors that can be said to affect acceptance of this technology. However, it should be clarified that after the above literature review, the authors believe that a link can be drawn between cobot acceptance and national context. This is why the above research question also includes some aspects of national context, mainly national policies and means of promotions, and their potential effect on acceptance.

1.4 Delimitations

This research is conducted with the following delimitations in mind. As the purpose is to provide an overview of factors that potentially affect cobots acceptance, it is outside the scope of this study to provide in-depth analysis of these respective factors. Further, the study does not have the objective to quantify or measure cobot acceptance, but rather to identify factors that can be argued to affect acceptance. It is also outside the scope of this thesis to prove or test that any of these factors does indeed have an affect on acceptance. In addition, this study intends to focus on cobots in an industrial setting. Thus, collaborative robots that are used for social interaction, medical procedures and so on, will not be studied. Furthermore, the research regarding national policies and means of promotion will be delimited to one government body, the European Union. Policies and means of promotion outside of this region will, thereby, not be studied.
2. Theoretical Background

This chapter has the purpose of guiding the reader through previous research on technology acceptance and adoption. It presents an evolution of technology adoption models, going from the Diffusion of Innovations Model, to Technology Acceptance Model (TAM), to lastly, describe the Unified Theory of Acceptance and Use of Technology (UTAUT) model. After this, this study’s conceptual framework is presented.

2.1 Technology Acceptance and Adoption

It has been shown that users’ attitude towards new technology, and also their acceptance of it, have a decisive impact on successful adoption (Venkatesh & Davis, 1996; Davis, 1989). In other words, if there is low acceptance of a new technology within an organization, the full potential of the technology will not be achieved and the company will not be able to fully enjoy its benefits (Venkatesh & Davis, 1996; Davis, 1993). Therefore, before a new technology is adopted, it is important that employees commit time and effort to learn and use the newly introduced technology. Only after this happens, can a company make the assessment whether the new technology is worth the investment or not and also about how the users feel about it. Research has shown that this is in fact dependent on how employees perceive the technology’s effectiveness and usefulness, rather than the technology itself (Shani & Sena, 1994).

In order to explain the process of how, why and at what rate new technologies spread, the Diffusion of Innovations Model was created (Rogers, 1962). According to this model, four main elements have an influence on the spread of a new technology, namely the innovation, communication channels, time, and the social system in place. Rogers theorizes that not all innovations will have similar outcomes. Some may diffuse poorly and never be adopted, while other can diffuse fast and see their use become common. Different outcomes are explained with the use of three groups of variables, namely characteristics of the innovation, characteristics of the adopters, and, finally, context (Rogers, 1962).
The Technology Acceptance Model (TAM) was developed to be able to predict information technology acceptance and how it would be used in a work environment. As shown in Figure 1, it was established that Perceived Usefulness and Perceived Ease of Use of a technology are the main determinants affecting the views that potential users would have on a specific technology (Davis, 1989). Davis (1989) defines Perceived Usefulness as the degree to which a person thinks that using a specific system/technology would have a positive impact of their performance; and Perceived Ease of Use as the degree to which someone believes that using said system/technology would require low, or no, physical and/or mental efforts. In other words, TAM establishes that a higher probability of use of a new system/technology depends on potential users’ positive Perceived Usefulness and Perceived Ease of Use. Further, TAM makes it clear that Perceived Ease of Use can have a direct impact on Perceived Usefulness, but not the other way around (Davis, 1989).

![Figure 1: Technology Acceptance Model (adapted from Davis, 1989)](image)

TAM’s basic framework showed potential for improvement and this pushed researchers to include new additional external variables in order to adapt the model and make it more appropriate to the study of specific fields. Consequently, this resulted in numerous modifications and improvements of the model, which strengthen its explanatory power. This wide array of modifications pushed Venkatesh et al. (2003) to do a full review of the studies and models, and combined them in order to simplify the field. The combination of eight models, namely Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behaviour (TPB), Combined TAM and TPB (CTAMTPB), Model of PC utilization (MPCU), Innovation Diffusion Theory (IDT), and Social Cognitive Theory (SCT), ultimately formed the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003).
UTAUT brings forward two different sets of variables that affect both Behavioural Intention and Use Behavior, as seen in Figure 2. First, four core dimensions were established based on the variables included in the previous eight models, namely Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. The authors defined Performance Expectancy as being the degree to which someone believes that using the new system/technology in question will help improve his/her job performance. Secondly, Effort Expectancy is considered to be the degree to which the new system/technology is expected to be easy to use. The Social Influence variable has been defined as the degree to which someone feels like others deem it important for him or her to adopt and use the new system/technology. The final core dimensions, Facilitating Conditions refers to the extent to which an employee believes that an appropriate organizational and technical infrastructure has been put into place with the objective of supporting the use and adoption of the new system/technology. These four core dimensions are then expected to be potentially influenced by four control variables, namely Gender, Age, Experience, and Voluntariness of Use (Venkatesh et al., 2003).

![Diagram](image-url)

Figure 2: Unified Theory of Acceptance and Use of Technology Model (adapted from Venkatesh et al., 2003)
2.2 Past Applications of UTAUT

As per its nature, UTAUT has mostly been applied to research in information technology and systems, including fields such as education (Thomas et al., 2013; Marchewka, Liu & Kostiwa, 2007; Ngai et al., 2007), mobile devices (Wu et al., 2008; Carlsson et al., 2006; Lu et al., 2005), banking (Yu, 2012; Im, Hong and Kang, 2011; AbuShanab et al., 2010) and health (Sharifian et al., 2014; Kijsanayotin et al., 2008).

Recently, the UTAUT model has started to be applied to robotics technology within some of these fields. In the field of education and care, for example, Conti et al. (2017) presented a study that focuses on the acceptance of robots by both experienced practitioners and future professionals that specialize in the rehabilitation of individuals with learning difficulties and/or intellectual disabilities. By using UTAUT, the authors aimed to investigate the factors that would have an impact on the decision of implementing a robot as an instrument within one’s practice (Conti et al., 2017). Overall, the results of this study has confirmed the UTAUT applicability to the acceptance and use of robots in a education and care setting (Conti et al., 2017). Further, factors and barriers to acceptance and use of robots in a healthcare setting was also analyzed through UTAUT (BenMessaoud, Kharrazi & MacDorman, 2011). By using the variables of the model, the authors were able to identify the reasons why robots were adopted, or not, by surgeons. They believe that their research could help the different stakeholders improve the proper adoption of robotic-assisted surgery (BenMessaoud, Kharrazi & MacDorman, 2011).

2.3 Government and International Technology Adoption

It has previously been shown that, in general, governmental institutions have the potential of impacting technology adoption as they have the ability to promote a specific technology through network effects (Hall & Khan, 2003). This effect implies that the value of goods or services may depend on the number of users, or even the nature of the users (Shapiro & Varian, 1999). Some technologies may be subject to stronger network effects than others. For those that do, it seems that long lead times and strong growth are the potential results, which originate from positive feedback. As the number of users increases, more and more people
will find adoption to be worth it and, eventually, this product or technology may take over the market (Shapiro & Varian, 1999). Adoption of a new technology can be influenced by the government’s ability to pass different regulations. Economic regulation may have impacts on market structure and size, market entry, and price-setting (Hall & Khan, 2003). In their study, Utomo and Dodson (2001) have established that direct government intervention is an important driving force for the promotion of technological innovation. With every new technology hitting the markets, governments have the challenge to develop the adequate regulatory oversight that successfully encourages competition and stimulates innovation while, at the same time, serving the needs of its citizens (Choudrie & Papazafeiropoulou, 2006; Lee-Kelley & Kolsaker, 2004). A number of empirical studies have argued for the role of such regulation on diffusion, including Laurence Baker’s study on how the provision of health insurance can impact the adoption of new medical procedure (Baker, 2001). In this study, it was found that adoption of new techniques and treatment methods was fostered through the implementation of a health insurance system providing certain reimbursements (Baker, 2001). Further, it has been suggested that economic instruments can be an efficient source of incentives for technology adoption, compared to ordinary regulatory standards. In addition, constraint inducing policies may also have the potential to create incentives, that can influence path to technological change (Kerr & Newell, 2003). Environmental regulations may also have an impact on new technology adoption as they may implement requirements or even prohibit the use of certain technologies and production methods (Hall & Khan, 2003; Gray & Shadbegian, 1998; Mowery & Rosenberg, 1989)

2.4 Conceptual Framework

In the previous part, it has been illustrated that the continuous development of technology acceptance models. As explained above, the UTAUT model was developed by combining eight models related to this field. As such, it is the authors belief that this model is most appropriate to use as a foundation for this thesis’s framework, as it covers more ground. Further, it was shown that the UTAUT model has started to be applied to studies related to the robotics field, and been so successfully. This thesis conceptual framework is, therefore, compiled with the UTAUT model as a basis for analysis. Certain changes and assumptions have, however, been made to the original model and this will be elaborated on below.
Firstly, as illustrated in figure 3, the UTAUT model has only served as an inspiration source, and has not been adopted in its whole. As previously stated, the purpose of this study is not to quantify nor to measure cobot acceptance, which is why the authors decided to focus this study on the UTAUT model’s ‘core dimensions’. For further clarification, these dimensions are only thought of as serving as a tool for analysis, and are not meant to be applied to the retrieved data. The definitions of these dimensions go in line with how the original model defined them, where the intention is to identify factors that could be said to impact the respective variables, which in turn, is argued to affect cobots acceptance. Secondly, as figure 3 shows, another variable has been included in this study’s conceptual framework. Through the literature review, the authors have found more studies strengthening what was suggested in the problem discussion, that governments can have an impact on technology adoption. For the purpose of this study, it was decided that there was no need for a clear separation between the concepts of ‘adoption’ and ‘acceptance’. While one does not necessarily lead to the other, the authors concluded that they can be said to be linked and that there is no need for a clear separation for the purpose of this study. This, in turn, implies that governments can be
thought of as affecting adoption as well as acceptance. Lastly, as shown in figure 3, the literature review lead us to not only draw a direct link to cobot acceptance, but to also suggest that a government can have an affect on two of the dimensions, namely Social Influence and Facilitating Conditions. As for the latter of these, Facilitating Conditions, it can be argued that a government's laws and regulations in regards to a technology, can affect the acceptance of the technology by an employee. In the case of the Cobot industry, this can be exemplified by having laws in place regarding who's to blame if someone were to get hurt. Government’s impact on Social Influence is thought of to more take place by its means of promotion. This could potentially lead to that someone feels like the government deem it important for them to adopt/accept a particular technology.
3. Research Methodology

*In this chapter the authors will explain and describe the research methods and critically discuss why those methods were chosen. The authors will also have a detailed discussion about the data collection process.*

3.1 Research Approach

The focus of this thesis is to investigate the development of the Cobot industry and the technology’s acceptance, using the conceptual framework as a tool for analysis. As this study aims to be explanatory in nature, researching why and how this industry is developing, a qualitative research method was adopted. The use of qualitative research method has been shown to be more suitable for studies that focus more on the ‘how’ and ‘why’ of things, studies made to understand and explain the meaning of certain actions. As opposed to quantitative methods, which tend to focus on the ‘what’ and ‘how many’, qualitative methods are used to investigate and build theories (Bryman & Bell, 2015; Marschan-Piekkari & Welch, 2004). There are many forms of qualitative methods. For the purpose of this study it was decided that the most relevant would be to use scientific articles, case studies, reports, interviews and industry panel discussions available online as the authors aim to adopt an explanatory approach. Multiple sources and cases are used to provide the reader with a broad picture and enough substantial data to be able to establish a pattern among the studied cases (Bryman & Bell, 2015). Using a large spectrum of sources, companies and industry actors gives us a better understanding of the development of the Cobot industry as the authors can compare multiple unique experiences surrounding the implementation and use of such products as well as factors driving/hindering the industry. While this study began with a deductive approach, the discovery of additional data throughout the process, lead the authors to go back and forth to adapt the theoretical background of this thesis. Consequently, an abductive approach was found to be the most appropriate. Taking on an abductive approach allows the researcher to continuously review and adapt its proposed framework and research question/s. (Bryman & Bell, 2015).
3.2 Research Design

3.2.1 Research Units

The units of analysis for the purpose of this thesis can be divided into three main groups. Firstly, previous published research about cobots, will serve as a foundation for this study. This in order to be able to provide a more comprehensive overview of the current drivers and barriers of cobot acceptance. Secondly, it was found relevant to add additional information to this by carrying out a detailed analysis of multiple users of cobots today. Lastly, a government’s perspective on cobots and its potential effect on cobots acceptance was added as a unit of analysis.

3.2.1.1 Literature review

The reason for using previous research is because it provides this study with a wide range of aspects of analysis that would have been hard to gather first hand under this time constraint. As described in the introduction, the purpose of this thesis is to provide a more comprehensive overview of factors that could be considered to be driving or hindering the Cobot industry’s development, and the technology’s acceptance. Thus, in order to provide a more extensive overview, it was deemed important by the authors to firstly gather inputs and research published by others.

3.2.1.2 Users

Companies implementing cobots into their operations provide a good understanding of the current and future state of the demand. Cobots certainly change the way firms operate, and by investigating their experiences, the authors wanted to seek out factors that might affect this demand. Getting the point of view of companies purchasing and implementing collaborative robots, and most importantly their employees, provides this study with a better base to understand the development of cobot acceptance. As workers are the ones that use collaborative robots on a daily basis, it was important to gather data about their overall experience with the technology. Further, company managers were expected to provide us with data regarding the impact and future use of collaborative robots within their operations.
3.2.1.3 Government

As collaborative robots are a new type of product that interact directly with humans it can be expected that the regulatory and legal framework would be affected, and in turn, impact the development of the industry. At a regional or national level, governments can decide to express their support to the use and development of this new technology. Thus, it has to produce relevant norms and regulations, but also a strong framework to help the industry develop. As previously mentioned, research has shown that the different diffusion patterns of industrial robots are correlated with one’s national context, such as national policies and means of promotion towards the technology (Fleck and White, 1987).

Consequently, it was found important to look into what a government / public organization or supra-organisations is doing regarding this matter. The authors chose to exemplify the impact of a regulatory and legal framework through the EU due to the fact that it is the biggest robotics market in the world and where cobots seemed to be on the uprising. Thus, seemingly undergoing a transformative time within the Cobot industry.

3.2.2 Data Collection Method

As implied in previous sections, the authors deemed it to be suitable to use secondary data for the aim of this study. Using secondary data provides the researchers with the possibility to access a wide range of available data. To a certain extent, using secondary data also provides the researchers with an already existing network of industry players and supporters around the world, giving an IB perspective (Boslaugh, 2007). As the aim of this study has been to illustrate the developments in the Cobot industry by using several different actors scattered across different regions (i.e. producer, customers and a government body), the use of secondary data eliminated some of the potential barriers the authors could have faced. Further, the authors lacked proper industry contacts that could have made it easier to get in contact with people of interest, such as employees/managers of companies using cobots or Members of the European Parliament. Contacting such people ourselves may not guarantee a positive answer and could have affected the substantiality of the collected data.

As the purpose of this thesis is to provide a more comprehensive overview of the Cobot
industry’s development, especially in terms of acceptance, it was decided that secondary data was the best available option to achieve this. The main reason why secondary data was deemed a better source than primary data for this study, was that primary data would have been too time consuming in order to provide an amount of data that would have been as substantial. By accessing already published work, this thesis could take advantage of multiple studies’ effort and time, that would have been otherwise out of the study’s time frame. In addition to this, it was found that primary data would not have been as valuable when trying to fill the first of the identified gaps, the lack of a comprehensive overview of the industry’s development, as this entails the gathering of previous research. Further, to use primary data in addition to secondary, were deemed to potentially take away valuable time and focus from the aim of this study.

In this case, the authors decided to firstly use published scientific articles as a the main source of secondary data. However, the authors also added other sources of published text, such as conference proceedings and industry reports. To capture a wide range of users, videos were collected featuring users as interviewees. For the collected videos, the authors decided to use Youtube as a data collection platform as it gave us access to a broad range of videos published by multiple relevant sources featuring cobot producers and users. Thus, giving us access to customers scattered over the world, operating in multiple industries and using cobots from three different producers. Further, interviews with Members of the European Parliament are widely available, eliminating the possible gap between us.

While the use of secondary data has its advantages, the authors are aware that it also has its disadvantages. First, researchers have to deal with the fact that the data was not collected based on their own research questions, meaning that it may lack specific information relevant to their case. Also, the researcher does not have full control on the geographic regions and years where the collection took place. In other words, the researchers have to deal with what has been done before. Another disadvantage comes from the fact that the researchers did not participate in the process of data collection. This leaves the planning and execution somewhat unknown to the researchers. In fact, the researchers do not know if the data collectors encountered problems such as low participation or altered responses (Boslaugh, 2007). Further, researchers have to be aware of the quality of the secondary data. In this case,
customer/user videos published by cobot producers were meant as marketing material. Consequently, it was important for us to understand that the material may have been edited and scripted towards a certain perspective.

3.2.2.1 Users Perspective

Searching for users’ point of view on the application of collaborative robots led us to multiple customer stories published by cobot producers on their Youtube channels. While the authors were aware that these videos were not the most unbiased source of data, the authors established that they presented relevant information for the purpose of this study. However, with that said, the authors believe that it is important to keep in mind that it is in both the producer’s and the user’s best interest to highlight positive aspects in these videos, as they are considered to be promotional content. As such, this is something that needs to be taken into consideration when analyzing the content of these videos. The authors do, nevertheless, believe that these videos can contribute to a better understanding of aspects related to cobot implementation and, in turn, cobot acceptance. Further, the authors intend to use other sources, such as scientific articles, to back up the empirical data retrieved from these videos. While these videos might not be completely unbiased, the authors do not believe them to be untrue, but rather that they might depict a more flattering version of cobot implementation than in reality.

Most cobot producers have such videos on their Youtube channel but the authors decided to narrow the selection to three main companies having international operations: Rethink Robotics, Universal Robots and KUKA. This choice was based on the origin of each company, the type of product they were producing, the nature of the videos available on their Youtube channels, and the size of the companies. In regards to both Rethink Robotics and Universal Robots, the number of videos available played a decisive role. In fact, these companies have hundreds of videos published on their channels, including numerous videos relating customer experiences, which made this case study approach possible. A total of 41 videos were used, each including between 1 and 5 speakers, totalling 86 people.

3.2.2.1.1 Universal Robots (Case Studies 1-22, Appendix 1)

With its headquarters and production line based in Denmark, Universal Robots (UR) sales its
products across the world. Between 2012 and 2016, the total number of robots deployed by UR almost tripled, going from about 3,500 to more than 10,000. The company was acquired by Teradyne for 285 million dollars in 2015. Teradyne is considered to be “the leading supplier of automated test equipment used to test semiconductors, wireless products, data storage, and complex electronic systems”. (Universal Robots, 2017a). Out of the 100 videos available on their Youtube channel (see link below), 22 were used for the study. Some videos that were not used were doubles published in a different language and others were compilations, some did not feature interviews.

Universal Robots (2017b), Case Studies:
https://www.youtube.com/playlist?list=PL0CpsfurQHiLxpPvl051FsD0mh100rh4

3.2.2.1.2 Rethink Robotics (Case Studies 23-40, Appendix 1)

Rethink Robotics, founded by former MIT Professor Rodney Brooks, was first in the world to launch a cobot, called Baxter. The U.S. based company later on launched its second collaborative robot, named Sawyer, and today, the company has around 100 employees with headquarter and production in the U.S. Baxter and Sawyer are currently deployed in a wide variety of industries, such as electronics, plastics and automotive. Further, the company has operations in several different regions, such as the U.S., Europe and Asia (Rethink Robotics, 2016a). Out of the 24 available customer stories on Rethink Robotics’ playlist ‘Customer Testimonial’ (see link below), 18 videos were used for the purpose of this study. The ones that got sorted out were either duplicates or illustrating the cobots in action.

Rethink Robotics (2017a), Customer Testimonials
https://www.youtube.com/playlist?list=PLE7Pue7SRXZFyOdw2ATKrhuMgyMFrH

3.2.2.1.3 KUKA (Case Study 41, Appendix 1)

Based in Germany (now chinese owned), KUKA is “one of the world’s leading suppliers of intelligent automation solutions” (KUKA, 2017). With more than 12,000 employees, its international operations generate around 3 billion euros per year. They provide various types of automation solution, including collaborative robots, to customers operating in a wide range of industries (KUKA, 2017). KUKA’s Youtube channel did unfortunately not include a
variety of videos meeting this study’s criteria. There was, however, one video that was found to provide insights to the study (see link below). Including one video clip from KUKA was based on the fact that the authors wanted to showcase that bigger corporations are getting into the development of collaborative robots. The company featured in the video, Skoda, is also a big multinational corporation part of the Volkswagen Group. Therefore, the authors believe that this is a good example to include as it reflects a big multinational corporation.

KUKARobotGroup (2017), People Work Directly with Robots Building Volkswagen Transmissions:
https://www.youtube.com/watch?v=c3GZ2Q0QLP8

3.2.2.1.4 Main Themes From Customers Stories

As the authors were dealing with secondary data, the choice of the main themes for analysis of customer stories needed to be based on what was discussed in those videos. In other words, the authors had to adapt to the data. To the study’s advantage, the videos usually provided similar information. These main themes of analysis are: easy of use, ease of adaption, technological precision and fit, safe around humans, value-add, product development, return on investment (ROI), improved product quality, improved cycle time, culture and organization culture, and concerns of jobs. The main themes of analysis were later summarized in a table that can be found in Appendix 1.

Appendix 1 is also meant to serve as a referencing tool. The reader can use this table to identify which and how many companies have mentioned the main themes respectively. For instance, in regards to ease of use, the table shows that 36 companies have mentioned this during their interviews.

3.2.2.2 Government Perspective

Searching for data relating to the point of view of lawmakers and government bodies led us to multiple interviews retrievable online. These interviews featured experts such as Member of the European Parliament, lawyers and researchers highly involved in the development of a new regulatory at and legal framework for the robotics industry. In regards to Members of the European Parliament, interviews of Therese Comodini Cachia (Malta), Mady Delvaux
(Luxembourg) and Michał Boni (Poland) were gathered. These were deemed relevant for the study as they are all active in the ongoing debate surrounding the development of a new regulatory and legal framework concerning the robotics industry (European Parliament, 2017a, 2017b, 2017c). In addition, they all participated to the Report with recommendations to the Commissions on Civil Law Rules on Robotics (European Parliament, 2017d). Data was also gathered from experts involved in the Robolaw project, which was partially funded by the EU (RoboLaw, 2017). Further, interviews taken place during the European Robotics Week 2016, an event sponsored by the European Commission, were used to get insights from other industry insiders. For the purpose of analyzing what was being done in regards to the development of a new regulatory and legal framework, the most relevant interviewee was Chris Holder, partner at Bristows Law Firm. In fact, he has recently been focusing on laws involving robotics and artificial intelligence.

The main empirical findings were based on the videos found below, featuring the people of interest to this study.

EPP GROUP (2017), Rules on robotics to protect citizens and boost the sector
Interviewee: Therese Comodini Cachia
https://www.youtube.com/watch?v=_DVrDFvl5M&feature=youtu.be

Interviewee: Mady Delvaux
https://www.youtube.com/watch?v=ylHvCZqGPXk

Eu Reporter (2017), #Robots: ‘Many threats are related to myths’
Interviewee: Michał Boni
https://www.youtube.com/watch?v=NJMiO5VyNt4

European Parliament (2017e), RoboLaw: Regulating robotics
Interviewee: Erica Palmerini, Andrea Bertolini
https://www.youtube.com/watch?v=pZfsam-6g0o
EuRobotics aisbl (2017), #ERW2016 Interviews

Interviewee: Chris Holder, Partner at Bristows Law Firm

https://www.youtube.com/watch?v=kHqJhxSK0PY
4. Empirical Findings

This chapter has the purpose of guiding the reader through the empirical findings. Throughout this research the authors have found a number of recurring themes surrounding the adoption and acceptance of cobots. The following sections will cover these common themes as reflected in the data collected, presented in accordance with the conceptual framework. In section 4.1, the authors will present the data that has been collected from literature (i.e scientific articles etc.). Later in section 4.2, the findings from published videos (i.e interviews with government officials etc.) will be presented. Lastly, the authors will provide a summary of the findings in section 4.3.

4.1 Empirical Findings: Literature

4.1.1 Performance Expectancy

4.1.1.1 Trends Driving Human-Robot Collaboration

For decades, companies have been outsourcing their production lines to countries with lower labor costs, such as China or other countries in South-East Asia. Since then, these countries have gone through a strong development path, which has resulted in rising labor costs (Bloss, 2016; Capgemini Consulting, 2013). For instance, Chinese labor costs are increasing at rates around 10-15% per year, which reduces the country’s traditional cost advantage (Capgemini Consulting, 2013). In order to be able to continue providing lower production costs to companies, manufacturers in such countries are turning to automation solutions, such as cobots, in order to maintain their competitive advantage (Capgemini Consulting, 2013). In fact, statistics have shown that the robotics market has grown faster in China than anywhere else, with sales of industrial robots growing by about 25% per year on average between 2005 and 2012 (Capgemini Consulting, 2013). This rise in labor costs in traditional manufacturing countries such as China also seems to impact the use of automation solutions in other parts of the world. Companies that have been offshoring their production lines to, for instance, China, seem to have also turned to robotics in order to reduce their costs and reshore their operations (Bloss, 2016). The increase in labor costs, combined with the reduction of the costs of
robotics solutions, especially cobots, have further pushed companies to reconsider offshoring. At the same time as labor costs are increasing, the labor force has been growing older, which is also driving the need for robotic solutions. Moreover, it has been shown that younger people entering the workforce do not consider manual labor as interesting or attractive as they may have in the past. Having grown up in the electronics age, younger employees seem to be more interested in jobs that involve electronics technology (Bloss, 2016).

Another trend that is bringing complexity to the manufacturing industry is that of moving away from mass production to mass customization. For this, companies need higher flexibility in order to respond to continuously changing customer demands. Smaller batch sizes and made to order products are more and more common. Past automation solutions do not provide such flexibility. In fact, studies have shown that traditional robots are expected to only be able to carry out around 10 percent of these upcoming tasks. Cobots, on the other hand, have been argued to be a solution that provides companies with such needed flexibility (Bloss, 2016).

While the need for automated solutions has been increasing during the last few years, much has also happened on the cobot side of it all. Cobots are getting cheaper and cheaper, making it more affordable for companies of all sizes, including some that could typically not afford traditional industrial robots (Bloss, 2016; PWC, 2014). At the same time, their programming has been simplified, making it easier to implement and use (Bloss, 2016). Most cobots that are already available on the market can be handled, transferred and reprogrammed from application to application by a single human. The possibility to repurpose the cobot has future positive impacts on the return on investment (Bloss, 2016). Combined with cost reductions, the growing number of potential applications has brought forward the possibility to introduce robotics solutions in industries where their use is not traditional, such as in food and beverage (PWC, 2014).

4.1.1.2 Benefits Rising from Cobot Implementation
Implementing robots into the production can have significant cost and efficiency benefits. By replacing several workers, a robot can lower operational costs by working faster while staying highly efficient. Further, a robot can eliminate time consuming and waste related
costs by reducing the need for reworks, scrap rates and the use of materials. This can result in higher and more consistent product quality. Introducing automation solutions such as cobots in the production line, can have a positive impact on safety and overall working conditions as tasks deemed dangerous or too difficult can be taken away from humans (BCG, 2017; Capgemini Consulting, 2013). However, while cobots have been found to perform some tasks better and more efficiently that humans, researchers at TU Dortmund University have found that cobots are unable to perform certain other tasks (Bloss, 2016). Thus, the need for human workers will continue to exist. A study at the University of Tokyo has shown that human-robot collaboration provides significantly more benefits than a production line with robots only (Bloss, 2016).

4.1.1.3 Barriers to Cobot Implementation
While much of the current research is investigating the upsides and drivers of cobot implementation, there are some that points out the technology’s limitations and barriers. Some have expressed that the cost is still viewed as too high in relations to the perceived needs (PWC, 2014). However, other research has found that it is rather the lack of potential applications and not the price that is the main reason why some cobots have not been adopted to a greater extent (Shikany, 2014).

4.1.1.4 The Spread of Cobots: Differences Between Countries and Industries
According to research, the spread of cobots will vary between countries and industries, depending on their respective characteristics (BCG, 2017; Bloss, 2016; Shikany, 2014). Robotics seem to be set to increase its adoption in many sectors as the share of tasks performed by robots are globally on the rise and expected to reach 25% by 2025 across all manufacturing industries, up from 10% in 2015. This may be in part explained by the decrease in costs and increase in performance of such robotics systems (BCG, 2017).

It has further been suggested that the adoption of cobots within the different industries, can come to vary depending on current domestic manufacturing wage and the ability to actually automate tasks (Bloss, 2016). The following table showcases which industries are most likely to adopt cobots depending on the wage gap, in order of decreasing likelihood.
Table 1: Industries Most Likely to Adopt Cobots, (Palme, 2015)

<table>
<thead>
<tr>
<th>Industries most likely to adopt cobots in countries with wage rates up to 40 per cent higher than the global rate</th>
<th>Industries most likely to adopt cobots in countries with wage rates up to 40 per cent less than the global rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation equipment, computer and electronic products, machinery, electrical equipment and appliances and leather</td>
<td>Plastics, apparel, textile mills, wood products and furniture, leather, food and beverage products, printing, fabricated metal and non-metal mineral products</td>
</tr>
</tbody>
</table>

The different adoption rates between countries seem to be, in parts, influenced by the levels of costs associated with manufacturing. Some high-cost countries, such as Canada, Japan, South Korea, the UK and the US, are currently at the forefront of robot deployment. These countries are expected to witness substantial savings in labor costs and thereby influence their overall cost competitiveness compared to the laggards. Higher robot usage is expected to decrease the average manufacturing labor costs, which, by 2025, should be about 33% lower in South Korea, and between 18 and 25% lower in China, Germany, the US and Japan. On the other hand, some high-cost countries such as Spain, Russia and Austria, that still lag behind in the deployment of robotics, will see their competitiveness decrease. It should, however, be noted that some countries with lower labor costs, such as China and Thailand, are deploying robots at a faster rate than expected (BCG, 2017).

Usually companies increase their investments in automation when labor costs become too high compared to what would cost to own and operate robots. According to BCG (2017), this adoption gap seems to be when human labor becomes around 15% more expensive than robotic labor. So far, even though with the increasing wages globally, this gap has yet to become small enough to cause mass deployment of robots. Further, the timing of the switch to robotics is different from industry to industry, and from location to location (BCG, 2017).

Different industries find the need for cobots and transition to adopting them at different speeds. For instance, companies operating in the aerospace industry have been implementing more and more collaborative robots within their operations. Similarly to other industries, this
rise in cobot implementation has not reduced the need for humans and industry insiders do not see cobots as threats to jobs, but more as productivity enhancing tools. Cobot implementation has resulted in an increase of efficiency, a reduction of chronic injuries, and has provided operators with more healthy, interesting, and rewarding jobs. Even if this technology has been adopted early by the aerospace industry, many seem to hope for more and better functionalities. The growth of cultural acceptance may in fact bring an increase in new possible applications for cobots (Shikany, 2014).

Over the past decades the automotive industry has been the largest driver of the robotics industry and, today, automotive companies are finding ways to use collaborative robots within their production lines. Automotive companies have been enjoying cobots’ ergonomic advantages by using them to accomplish dull, dirty and dangerous jobs, while at the same time increasing output quality. Cobot implementation also has resulted in lower production costs and has reduced the floor space needed to produce parts. However, automotive companies still seemed to have certain concerns relating to the cost, availability and capability of these cobots (Shikany, 2014).

The electronics industry is also making a shift towards installing cobots, bringing employees to different jobs. This shift does not seem to worry employees as many of them are excited about integrating new, less dangerous and more interesting roles. In addition, it seems that employees agree on the fact that cobots are easy to install and use. However, some areas in electronics have yet to integrate cobots, such as in assembly, resulting from high costs. In order for cobots to integrate these sections, improvements in vision, feeders and dexterity were needed. In addition, electronics companies seem to give a lot of importance to cobots’ ROI and cost of implementation (Shikany, 2014).

An increased usage of robotics and automation solutions in the plastics industry seems to have been taken place and cobots have been part of these changes. Productivity seems to have increased as some users have had their cobots operate non-stop. Human employees appear to be happier as they are taken away from repetitive tasks and only have to supervise the robot once in awhile. Common to other industries, companies have expressed their wish for better
software and hardware in order to be able to integrate such cobots in various more operations (Shikany, 2014).

Overall, it seems that cobots are to be more and more implemented across different industries. These industries all have their specific wishes when it comes to the future development of this technology. Some, such as the aerospace and automotive industries, would require stronger payloads and increased speeds, while others, such as plastics and electronics, would require easier programming and better precision (Shikany, 2014). Automation solution seem to no longer be reserved to large companies within these industries as cobots are seen as as positive solution for SMEs that previously did not have the proper resources to automate their operations. Combined with the facts that cobots are more affordable and take less space than classic industrial robots, they can be operated by any worker, without any specific qualifications (IFR, 2017).

4.1.2 Effort Expectancy

4.1.2.1 Barriers to Cobot Implementation
Other barriers that have been found to be hindering the adoption of cobots include aspects, such as, a lack of perceived expertise and skills (PWC, 2014). In an interview given to Capgemini Consulting, Dr. Per-Vegard Nerseth, Group Vice-President and Head of Robotics at ABB, identified that challenges were related to ease of use and safety (Capgemini Consulting, 2013). It was argued that, for cobots to be more widely adopted, they had to become easier to use. As the automotive industry has been working with robots and automation for a long time, the industry’s workforce developed the proper skills and expertise required to successfully integrated cobots. Other industries, however, may lack such knowledge. Consequently, cobots had to become more user friendly and easier to operate (Capgemini Consulting, 2013).

4.1.2.2 Cobots as co-workers
According to multiple research, the acceptability of cobots as co-workers is influenced by multiple factors. Goetz et al. (2003) have brought forward the importance of robot appearance by suggesting that people’s perception of a robot and subsequent cooperation may be influenced by how it looks and behaves. The authors also suggest that people’s perception
and responses to the robot are also influenced by expectations regarding the robot’s role in different situations (Goetz et al., 2003). Further, the robot's movements seem to also influence the acceptability of human-robot collaboration (Kupferberg et al. 2011; Huber et al. 2008; Kulic and Croft 2007; Nonaka et al. 2004). Karwowski and Rahimi (1991), concluded in their study that aspects of the robot that may influence acceptability are its behavior, speed, and safety distance. More recently, Aria et al. (2010), in a novel cell production assembly experiment, found that robot size and robot speed had increased mental strain.

In line with the paragraph above, Weistroffer et al. (2013) set out to evaluate people’s acceptability of human-robot collaboration based on people’s perception of the robot's movements and appearance. By exposing respondents to collaborative task with four different robots, the authors were able to draw conclusions in regards to the perception of human like features and movements. First, their results have shown that working with a humanoid on a collaborative task may be disturbing and some respondents did not see the utility for the robot to have two arms in order to complete the task. In fact, a one-armed robot designed for collaborative task was preferred. This shows that stronger human-like features may not lead to higher acceptability. While some human-like features are appreciated, combining them with human-like movements was deemed perturbing. However, respondents did respond well when human-like movements were added to the behavior of an industrial robot. With this information, the authors drew a link between safety and competence of the robots, and more mechanical movements. The trade-off between having human-like appearance or movements may come from the uncanny valley effect. It implied that when building a robot, one should either focus on its movements and capabilities or its appearance. Human-like appearance combined with human-like movements did not project good perception among respondents while robot-like appearance combined with human-like movements did, and so the other way around (Weistroffer et al., 2013).

Elements influencing the acceptability of human-robot collaboration have been linked to the environment where robots are being implemented. While studying the impact of robots on working conditions, previous research has also provided conceptual models outlining the importance of considering the working environment before implementing such human-robot collaboration (Ding et al., 2013, Hayes and Scassellati, 2013, Klamer and Ben Allouch, 2010;
Katz et al., 2008). Further, acceptance in the work environment seems to be highly influenced by the potential flexibility a robot could provide the worker, and the potential efficiency of their collaboration (Strassmair and Taylor, 2014). However, while the implementation of cobots may reduce physically demanding jobs for humans and provide them with more flexibility, jobs requiring more cognitive performance have increased. For the collaboration to be effective, it has been argued that a good workload balance would have to be considered (Megaw 2005).

Kim et al. (2015) concluded in their study that workers seem to still value a certain separation between them and robots as they perceive it as providing more safety, trust and team identification. In order to be able to grasp human perception of robots, one has to take into account the work environment where the collaboration takes place. More than taking into account the work environment, people's' own biases and characteristics can also have an effect on one’s perception of human-robot collaboration, which may in turn affect acceptance and adoption. All things being equal, perception may differ, even within the same work environment, based on age, personality, previous experience with new technologies etc. Their study showed that workers seemed to feel less secure when sharing a work environment with a robot, and express less trust towards the robot. Sharing working space can also negatively impact team identification (Kim et al., 2015). Charalambous et al.’s (2013) study further discussed how human-robot collaboration, which implies close proximity between the two, may lead to collisions and potentially create stress and anxiety issues. Strassmair and Taylor (2014) and Charalambous et al. (2013) further showed that spatial constraints are important to consider when implementing a human-robot collaboration in one’s operations as human behaviour seems to be influenced by the robot’s proximity.

Looking into having robots as co-workers seems to have brought researchers to extensively study safety concerns. As the implementation of cobots implies physical interaction between humans and robots, safety has to be guaranteed. Past research has established that human perception of collaborative robots has an impact on how much someone will trust a robot as being a team-mate. Building a strong human-robot collaboration seems to rely in part on trust, as it has been shown to influence the success of the interaction (Billings et al., 2012). It was previously suggested by Hancock et al. (2011) that factors such as robot performance
may have a strong impact on trust. Further, perception and trust seem to be also linked to safety and team identification (Sanders et al., 2014; Tang et al., 2014; Van Den Brule et al., 2014; Hancock et al., 2011). With this in mind, some studies have been conducted with the objective of improving necessary features such as obstacle avoidance (Pedrocchi et al., 2009), safety evaluation of robots (Haddadin et al., 2007), and intrusion detection (Lenz, 2011).

4.2 Empirical Findings: Videos

All sections between 4.2.1 and 4.2.4 cover data received from video-interviews with cobots users, based on promotional videos published by robot producers. A total of 41 videos were used, each including between 1 and 5 speakers, totalling 86 people, all of which were used to create the following sections. The authors would like to advise the reader to keep in mind that it is in both the producer’s and user’s best interest to highlight positive aspects in these videos. Sections under 4.2.5 are based on videos covering interviews about the EU’s ongoing developments in regards to the Cobot industry. Please see section 3.2.2 for references for the respective parts.

4.2.1 Performance Expectancy

4.2.1.1 Reasons for Cobot Implementation

Most companies integrating collaborative robots in their production lines have shown a strong interest in new technologies. They tend to believe that it is crucial to improve one’s technology in order to stay competitive. Companies were looking for new ways to improve their productivity, efficiency and speed, as illustrated in Tag Team Manufacturing:

“One of the main reason why we invested in the Sawyer robot was because the order that we were receiving and the ship dates that we had to meet, were such a close tolerance that we did not have the resources or the capability to produce that volume in that short of time.” - Terry Taggart, CEO, Tag Team Manufacturing (Rethink Robotics, 2016c, Case Study 27, 0:17-0:41/2:14)

It was important to make the production lines more reliable and precise while also increasing
control. When looking for automation solution, most companies have had a look into regular industrial robots but had to decide against them. In fact collaborative robots were preferred as they would take less space, are cheaper, provide strong flexibility and are meant to interact with humans. Employees were also taken into account when making the decision of acquiring cobots. By integrating cobots into their production lines, companies had the intention of improving the work environment of their employees, especially for those having repetitive tasks in their daily workflow. Collaborative robots took over the hard, repetitive and dangerous tasks, bringing people to tasks requiring more creativity and thinking.

4.2.1.2 Benefits Rising From the Implementation

The implementation of collaborative robots has brought many benefits to companies using them. By being fast and accurate, product quality was largely improved and companies have managed to greatly reduce the percentage of defects. In fact, Tuthill decreased defects by 98% while RUPES and Škoda were able to completely eliminate them. Further, it was possible for companies to reduce waste material and production costs. Consequently, productivity and efficiency were increased, bringing higher returns and more economic and stable operations. In addition, cobots also made it possible for companies to keep up with continuously rising demand, as illustrated in Tegra Medical:

“Because we were able to double the throughput from the process we've been able to keep up with customer demand which was previously a challenge for us. It's also allowed us to offer cost reductions because we take that operator out of the cell and replace it with the robot. That's a direct cost savings to both us and the customer” - Hal Blenkhorn, Director of Manufacturing Engineering, Tegra Medical (Universal Robots, 2015d, Case Study 13, 3:16-3:32/5:02)

4.2.1.3 Return on Investment

All companies seem to be satisfied with the return of investment and payback period as it optimized production and reduced staffing costs in some cases. Among the companies studied, the payback period was between 34 days to 18 months, with an average of about 9 months.
4.2.2 Effort Expectancy

4.2.2.1 Experiences From Cobot Implementation

Some companies, such as LEAX, expressed concerns regarding safety, as the cobot would be working in direct contact with their employees. Further, another strong concern expressed by companies was the fact that it was thought that the implementation of cobots would result in the reduction of the human workforce. Moreover, companies were also worried about how to motivate their decision to integrate this new technology and how to provide the adequate training to their staff.

After implementing collaborative robots, companies saw their performance expectations met and their concerns overshadowed as these robots were indeed designed to work with humans. There was a clear improvement of the work environment as workers were relieved from repetitive, dangerous, dirty and dull task, while at the same time increasing the overall safety. Also, companies noticed that the implementation process was way easier than expected. Companies now have the possibility to place the robot wherever they want and easily train it to do whatever they want.

4.2.2.2 Cobots as Co-Workers

When collaborative robots were first introduced, some companies’ employees were sceptical, as illustrated in Scott Fetzer Electrical Group:

“When the robots first came out on the floor, employees were very anxious and a little nervous about it. But, now that they're out there on the floor, they act like they can't live without them. They are constantly asking ‘can we put a robot in this position’, ‘could we maybe put a robot in this position’. You know there there's a lot of people who are trying to figure out where we can put our next robot to help our process.” - Sebrina Thompson, Line Lead, Scott Fetzer Electrical Group (Universal robots, 2015b, Case Study 11, 2:36-3:02/4:44)

The above quotation also illustrates that, once properly introduced to cobots, employees saw
the benefits and potential of implementing such technology. Their user friendliness made it easy to implement as no prior experience was required to operate them successfully. This provides the companies with the benefit of not having to hire specialized workers or spend time training their employees on how to operate these new machines. The ease of use and programming also provides the companies with much needed flexibility as they can easily transfer the robot to a new working station without too much effort. These benefits extended to the workers by significantly improving their daily workflow, as illustrated in Marka:

“The UR3 has made my life easier because it can be used by a non specialized operator working alone who can stop, reset and restart the articulated arm without needing to stand next to the machine. It is very easy and intuitive and requires no safety guarding.” - Sergio Melite, Production Technician, Marka (Universal Robots, 2016a, Case Study 2, 2:53-3:09/3:45)

Further, workers seem to be very happy and receptive when it comes to having a collaborative robot as a co-worker. In fact, they were pleased to get the opportunity to get away from unpleasant tasks and think differently. In some cases, employees even qualified the robots as being fully integrated and actual members of the team, even going to the point of qualifying it as a person, as illustrated in Vanguard Plastics and Stanträk:

“I don't see him like a robot, I see him like a person. I feel good with Baxter here, very happy.” - Mildred Martinez, Shipping Manager, Vanguard Plastics (Rethink Robotics, 2014d, Case Study 36, 2:27-2:34/2:48)

“The robot does what you ask it to do and never complains. It's very comfortable to work with, so it's a nice colleague to have” - Poul Lave, Machinery Operator, Stanträk (Universal Robots, 2013a, Case Study 18, 0:42-0:49/2:52).

In some cases employees even made sure that the cobot looked like an employee, by either putting a employee badge around its “neck”, giving it a name or by dressing it up.
4.2.2.3 Intentions of Future Use

With the success that collaborative robots brought, the studied companies have implied that they will make efforts to find new useful applications. Companies have the ambition the deploy these machines to a larger scale as they see the great potential and future growth they would bring. In fact, some of the companies said that they view collaborative robots as the go-to solution for the future of their industry, as illustrated in MS-Schramberg:

“In a few years systems, like Sawyer, will be an integral part of our industry and we won’t be able to imagine life without them. In high wage countries like Germany, for example, this approach will be indispensable” - Norman Wittke, CEO, MS-Schramberg (Rethink Robotics, 2017c, Case Study 24, 2:29-2:50/3:16).

Whether it is to further develop their production lines, to automate other aspects or to provide employees with a better work environment, companies have expressed a strong interest in purchasing more collaborative robots in the near future. As an example showing a fast integration of collaborative robots is Trelleborg, which went from not using any robotics solution to incorporating 42 collaborative robots in a two-year span.

4.2.3 Social Influence

4.2.3.1 First Introduction to Cobots

Initially, many of the studied companies heard about the cobots through their business networks. MS-Scramberg heard about Rethink Robotics’ Sawyer through a company they were closely collaborating with, and Orkla got a tip from a local business that already had implemented one of Universal Robots’ products. Similarly, Škoda were looking to improve their production line and hired Matador Group, one of their long time partners. Matador Group subsequently advised Škoda to include human-robot collaboration in its production line as it was seen as the future of manufacturing. Further, hearing that other companies had implemented cobots into their operations provided another incentive to move forward with their own implementation, as illustrated in Glidewell Laboratories:
“I think hearing that BMW were using it was, you know, a good vote of confidence in the robot” - David Leeson, Engineering Manager, Glidewell Laboratories. (Universal Robots, 2015f, Case study 15, 0:40-0:48/4:57)

For other companies such as Trelleborg, the implementation of collaborative robots came somewhat naturally. The company had been looking into implementing robots in their production line for about 15 years but never came across a solution that fitted their needs. Regular industrial robots required safety cages, which was unattractive for Trelleborg as they did not have the space to accommodate such modifications.

4.2.3.2 Company Culture

The implementation of collaborative robots came with a few concerns. As the technology is relatively new and not so widespread yet, some companies were anxious about how the technology would work in their specific contexts. However, not all companies studied had this perspective, as illustrated in RUPES S.p.A:

“When we met the concept of collaborative robot, it was like turning the light on for us. It perfectly matches our philosophy where the human factor is still one of the key point. Now to see the robot doing all the repetitive stuff together with our people, it is something that makes us proud.” – Marco D’Inca, R&D Manager, RUPES S.p.A (Universal Robots, 2017c, Case Study 1, 3:01-3:24/3:38)

The above quotation illustrates that the decision to use collaborative robots also has to be aligned with the company’s philosophy and organization culture.

4.2.3.3 Perceived Impact on Employment

As it was shown earlier, one of the main concerns was that collaborative robots would cost jobs. However, companies have realized that humans are still a key factor and cannot be dismissed. In some cases, collaborative robots have actually been at the forefront of job creation. In the case of Trelleborg, the usage of collaborative robots led to an increase of production and demand. In turn, this made them hire 50 new employees for one of their production site in Denmark. On the employee side, people are not that concerned anymore as
they now have much more interesting, exciting and fulfilling roles within their respective companies. In addition, collaborative robots may disrupt the manufacturing industry by reversing outsourcing decisions, as illustrated in Scott Fetzer Electrical Group:

“We can compete with anybody. We're bringing back business that used to be in China or that we use to source in China. We've been able to reallocate some of our employees to other areas where we've seen growth in our business” - Rob Goldiez, General Manager, Scott Fetzer Electrical Group (Universal robots, 2015b, Case Study 11, 2:17-2:29/4:44)

4.2.4 Facilitating Conditions
The data collected from the videos have put to light a common strategy of producers, that involves being part of the adoption and implementation process of cobots. In fact, after hearing about the cobots through different channels in their networks, it was common for the customers to have a chance to experience on-site demonstrations of the robots prior to committing to them. Further, customers were provided with professional guidance and training sessions in order to find the right application for the cobots within their respective production lines, and were typically granted a trial period. Finally, as part of their after-sales strategy, cobot producers seemed to offer continuous support to their clientele.

4.2.5 Government Influence

4.2.5.1 Reasons Behind the EU’s Position in the Industry
Contrary to public opinion, the EU believes that robotics can be a strong tool for productivity, growth and job creation. The EU is today the world leader in industrial robotics with about 25% of the global market. According to the European Commission, it is to be believed that by 2020, 90% of all jobs will require basic digital knowledge. Understanding the potential of this industry and technology, it is important for institutions like the EC to build the necessary framework in order to stimulate its growth while making sure all parties involved benefit from it. With this in mind the EC has been behind a number of projects in robotics.
4.2.5.2 The Development of the EU’s Legal Framework

As the robotics industry grows and develops it is important to build an appropriate legal framework. Current laws that apply to robots were made without having human-robot collaboration and AI (artificial intelligence) in mind. Robotics is developing in such ways that the new technologies bring up the need of updated laws and regulations. Moreover, as illustrated in the quotation below, the development of a legal framework can help such an industry to develop further:

“Understanding the technology, understanding the impact it is gonna have and having legislators from around the world creating laws that will help the technology develop and also help society deal with issues.” Chris Holder, Partner at Bristows Law Firm. (euRobotics, 2017, 12:12-12:28 /24:55)

The EU is trying to build laws and policies with the objective of creating European standards and best practices regarding robotics. So far, no member country has its own laws, therefore the EU can build the framework without having to consider each member’s policies. Members would adapt to the EU’s plan, and not the other way around. Even though some question whether regulations could hamper innovation in this industry, most seem to believe that it would do quite the opposite. In fact, the EU wants to make sure that the industry continues to develop by implementing legislation, as said by MEP Therese Comodini Cachia:

“We don't want to stop development in robotics or in technology, we just want to make sure that we do have the systems in place and we do have the regulation in place to see this development further” - Therese Comodini Cachia, Member of the European Parliament (MT). (EPP Group, 2017, 0:08-0:23/3:36)

As the above quotation illustrates, developing a legal framework can be a driver for growth. In fact, legal certainty can be a good basis to encourage research and development. This would also encourage technology adoption as companies and their employees would have better and stronger trust towards the implementation of robots, as illustrated by MEP Mady Delvaux:
“It has to be transparent and clear to the customer because otherwise [...] there will be no trust and that is what we need.” - Mady Delvaux, Member of the European Parliament (LX). (PressTV News Videos, 2017, 0:58-1:07/1:29)

The European Parliament is currently discussing a wide-range of issues concerning robotics, including liability rules, safety and security, data protection and employment. For example, many Europeans have expressed fear that automation could cost them their jobs. However, EU officials seem to believe otherwise, as illustrated by MEP Michał Boni:

“Many threats are related to myths. People are saying ‘okay robot will replace our work, we will have labor market without workers’ - it's not true because many jobs probably will be lost but many new will be created and we need to prepare some kind of transition period tools for people to adjust them with their skills to the new situation and adjust them mentally to the new situation.” - Michał Boni, Member of the European Parliament (PL). (Eureporter, 2017, 2:08-2:39/3:06)

More than not being a threat to employment, the EU sees robots as a great opportunity for growth and better working conditions. Productivity can rise by 85% when workers team up with robots and robots can take on more hazardous tasks.

4.3 Summary of Empirical Findings
The empirical findings have been presented following the structure of the conceptual framework of this thesis. In order to achieve this, the collected data had to be grouped into the respective variables of this framework: Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Factors and Government Influence. The main factors identified under each of these variables are illustrated in figure 4 below.
In the following chapter, the link between the identified factors and the conceptual framework’s variables will be explained and their potential effect on cobot acceptance will be further analyzed.
5. Analysis

This chapter sets out to present a discussion and analysis of the empirical findings chapter combined with the theoretical framework.

5.1 Introduction

At the beginning of this thesis, the authors had set out to answer the following research question:

*What main factors can be said to affect the acceptance of cobots as a new technology?*

The following sections of this chapter will now return to the research question, presenting the analysis and findings to the empirical data collected. The analysis will be presented in accordance with the conceptual framework’s variables: *Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Factors* and *Government Influence*. Under most of these variables, the analysis will be divided into ‘literature review’ and ‘users’. Thus, separating the two main sources of data; literature and videos.

5.2 Performance Expectancy

*Performance Expectancy is defined as being the degree to which someone believes that using the new system/technology in question will help improve his/her job performance.*

5.2.1 Literature review

Cobot acceptance seems to have been impacted by the changes in worldwide labor costs. Companies located in places where manufacturing costs have traditionally been low, such as China, and in high wage countries, have been implementing cobots in order to maintain their competitive advantage. On one hand, companies in China want to keep manufacturing jobs and, on the other hand, companies in countries like the U.S. are now seeing the possibility of reshoring manufacturing jobs. By affecting a company’s labor costs, cobots now seem to have the potential of impacting profits, which are a strong indicator of a company’s
performance. Consequently, it can be argued that a company’s *Performance Expectancy*, based on labor costs, can impact the acceptance of collaborative robots. As such, it is possible that as labor costs continue to increase, the acceptance of cobots will follow in the same path, assuming that their costs are held constant or decrease.

The labor force has been growing older and as these demographic changes continue, the need for robotic solutions can be argued to increase along with it. If there are less people around for manufacturing companies to hire, and these companies were to turn away from automation solutions, they would not be able to produce in the same scale and thereby, their performance would likely decrease. As such, it can be argued that the acceptance of cobots can increase if these demographic challenges continue as companies may have to accept cobots as a solution by necessity. In addition to this, younger people entering the workforce today are less interested in manufacturing jobs, which could add to the complexity of attracting people to this sector. In fact, the younger workforce has been found to be more interested in jobs that involve more electronic technologies, hence, acceptance of cobots in the workplace may come to increase as younger generations enter the workforce. Further, by integrating cobots, companies may be able to increase their performance by attracting younger and more qualified people.

Companies have been faced with demand’s recent need of more customization. In order to stay competitive in this new environment, companies have had to find solutions to increase their flexibility. As such, this may also have pushed companies to accept collaborative robots, in order to maintain or even increase their performance in today’s new business environment.

Cobots have been shown to provide companies with increased efficiency and product quality, which can directly impact *Performance Expectancy* and, thus, acceptance. However, the true potential of most of these benefits are arguably first realised after employees commit time and effort to learn and use the cobots. As brought forward by Shani & Sena (1994) in this study’s theoretical background, a company can not really assess the success of a new technology until some time has passed since the implementation. As such, even though most research points towards that companies that implement cobots can enjoy benefits that could arguably increase *Performance Expectancy*, which could increase acceptance, it does seem
like the relationship between *Performance Expectancy* and cobot acceptance is somewhat circular. Most of the gathered data illustrates that once a cobot was adopted within an organization, most employees came to see the benefits of this technology. At the same time, the data can be argued to reflect that one of the main barriers to cobot acceptance is that it was never implemented to begin with. While the next paragraph will go through some of the reasons why some companies do not implement cobots, the gathered data seem to indicate that companies that did implement agree on the benefits. It can be argued that these benefits were realised with time, and as such, acceptance can also be said to have increased with time.

While much of the previous research highlights drivers and benefits of cobots, which were argued to positively affect *Performance Expectancy*, some illustrated that not all find cobots to increase their performance, or rather that not all see the need for the technology within their respective industries. In fact, studies have found that for some industries, cobots do not offer the right solution as there are still no valuable cobot applications available. As such, the cobots are most likely not viewed as a technology that can yet be expected to increase performance. However, this does not necessarily mean that this affects acceptance negatively. Some of these companies might have an interest in the technology but are so far not able to implement cobots in their operations. While this can be the case, there also seems to be companies that simply views this technology as either not useful or still too expensive in relations to their perceived needs. As for this latter case, this can be argued to impact *Performance Expectancy* negatively, as the technology is not seen useful enough. In turn, cobot acceptance might be low. In addition, different industries have different needs and as such, companies have expressed what cobots were lacking in order to be considered as being able to increase performance. With developments in the technology, cobots may be able to withstand stronger payloads, operate faster, have higher precision, and provide companies with better ROI. These are qualities that some companies have found to be not sufficient enough, and if these were to improve, *Performance Expectancy* would increase along with it.

As it was mentioned, some countries have been adopting collaborative robots faster than other. This was linked to the different levels of costs associated with manufacturing. As some countries with high labor costs are at the forefront of cobot implementation, it can be argued that companies in these countries have a higher *Performance Expectancy* of cobots in
comparison with companies from other countries. Thus, cobots can be considered to bring labor costs down for companies and in this way, increase performance. There can, however, be other factors outside of the scope of this dimension that impact this trend, such as, government policies. However, it was also shown that other high cost nations still lag behind the implementation of collaborative robots and may face a decrease in their competitiveness. Consequently, high labor costs do not always positively impact Performance Expectancy and cobot acceptance.

5.2.2 Users

The findings uncovered some concerns that had been present within the studied companies before the implementation of cobots. Concerns about safety and loss of human employment, which could have a negative impact on performance, were common and touched upon by several of the actors within the industry. Due to the widespread of these concerns, especially amongst the users, it can be argued that this furthers the challenge of becoming an accepted technology. This can be argued to be linked to Performance Expectancy. Even though these concerns were later argued against by the customers presented in the empirical findings, the fact remains that some potential customers may still be skeptical towards cobots due to this perception.

Once the users had gained the knowledge about how to use the cobots, customers themselves became a part of the application as many of them were able to adapt the robot to their own needs by developing add-ons themselves. In some cases employees were able to get creative and find new and better ways to implement cobots within the production line. Cobots may have an impact on companies creative process as they push them to innovate and create in order to get the most out of the technology. Not only did this creative process allow the companies to get the most out of the cobots, but also get the most out of their employees. This can be illustrated through how cobots can relieve employees from dull and repetitive tasks, and thereby allow them to concentrate on more creative and intellectually rewarding, value added tasks. Interviewees have linked this positive impact cobots had on their employees to the improvement of their overall performance as productivity, efficiency and quality increased. As shown in Table 2, multiple respondents have mentioned benefits related to Performance Expectancy.
Table 2: Themes Related to Performance Expectancy (based on data collected, available in Appendix 1)

<table>
<thead>
<tr>
<th></th>
<th>Value Add</th>
<th>Improved Quality of Product</th>
<th>Improved Cycle Time</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents</td>
<td>17</td>
<td>11</td>
<td>33</td>
<td>15</td>
</tr>
</tbody>
</table>

While the authors are aware that some of the data collected reflects the current state of cobot implementation within the companies studied, it can be argued that these companies had in fact such expectancies prior to the implementation. Further, as the data is publicly available, it may shape Performance Expectancy of future users.

5.3 Effort Expectancy

Effort Expectancy is considered to be the degree to which the new system/technology is expected to be easy to use

5.3.1 Literature review

While companies market their cobots as easy to use, and users tend to agree, some companies seem to argue that cobots still need to become easier to use as they lack the required expertise and skills. In these cases the perceived Effort Expectancy can be argued to be high and thereby lead to a lesser degree of cobot acceptance. While in some cases, this could be said to be the other way around. Further, it was shown that ease of use differed from industry to industry, based on their past experiences with robotics solutions. The automotive industry, which has been at the forefront of robotic usage, has shown a better understanding of the technology and implemented cobots faster. In fact, over time, the automotive industry has been able to develop robotics knowledge and the appropriate skills and expertise. Consequently, companies have been integrating cobots successfully. Comparatively, industries that a newly turning to robotics solutions seem to lack the knowledge and may not yet have the appropriate skills to do so with ease. It can thus be argued that time and experience may have an impact on Effort Expectancy and, thus, cobot technology acceptance.
At a more individual level, cobot appearance, including how it looks and behaves, seems to affect acceptability. For example, it has been shown that a cobot’s size and speed can increase mental strain. By linking this to trust towards the cobot, it can be argued that a lack of trust can be correlated to a higher Effort Expectancy. An employee might have a harder time accepting a cobot as a co-worker if it does not feel comfortable using the technology, or, for example, feel that its movements are unpredictable. Thus, a smooth cooperation between worker and cobot can be argued to result in lower Effort Expectancy. Moreover, it has been shown that human like features and movement may have some impact on Effort Expectancy. A study found that the combination of both human like features and human like movement, did not necessarily lead to higher acceptance as it made people uncomfortable. In fact, it was shown that one or the other was preferred. As it was previously argued, being comfortable around the cobot may be an important aspect impacting Effort Expectancy and, thus, technology acceptance. Consequently, it can be argued that to minimize Effort Expectancy, cobots should reflect the appearance of an industrial tool.

Effort Expectancy can arguably also be linked to the work environment, in which the collaboration takes place. Studies have found that the cobot’s proximity can make the human feel less secure and cause stress and anxiety. As such, cobots can be viewed to have less Effort Expectancy when providing appropriate space to the operator. These studies, along with the ones described in the previous paragraph, illustrate that cobots are yet not a trusted technology and therefore not fully accepted. Other studies, also focusing on cobots as co-workers, have highlighted safety concerns. This has been argued to go in line with what was discussed above about trust and acceptance. Cobots have, however, also been argued to provide a safer working environment for employees, by taking over dangerous task. Moreover, it has also been shown that robot performance, which can include ease of use, can have a strong impact on trust. Thus, this again points towards that acceptance can come with time and experience.

5.3.1 Users

The data reflects that Effort Expectancy seemed to be high before the implementation of the cobots within some of the organizations, as employees expressed certain concerns. Some had no engineering background and had never worked in collaboration with robots, and were
therefore worried that they lacked the proper skills to operate the cobots. The perception that cobots required high efforts to operate can be argued to be one of the main barriers to technology acceptance. However, as these customers did in fact implement cobots within their companies, it is likely that either Performance Expectancy outweighed this concerns or that this perception was not shared by the directors of the companies. The findings illustrate the importance of networks and word of mouth to the first introduction to cobots. This may imply that these contacts had already experienced cobots and expressed that the cobots are easy to use.

The findings also reflect that workers thought it was easy to collaborate with the cobot once implemented. Most factory workers for example, have very little automation training or computer language training and multiple companies have described their experience and how quick after delivery a worker could make the cobot complete its first task. Through learning processes, companies can have a better understanding of the cobot and its possible applications and Effort Expectancy may decrease. By witnessing the potential uses of the technology and its easy implementation within the production line, it will affect the image people have of robots. Further, in most cases, it was brought forward that the cobots were a technological and precision fit, which made the implementation easier. Cobots can thus gain higher acceptance by the fact that they are easy to program and that they are user friendly. Safety has been a concern when companies started to introduce cobots on their production lines. While accidents might still happen, collaborative robots are meant to work alongside humans and are designed as such that human safety is not be jeopardized. Compared to regular industrial robots, no safety cages are required, which further argues to the easiness of implementation since less time, effort and investment are required. High safety standards may, in a way, allow the cobot operator to worry less about his or her safety, and focus more value-added activities. As shown in Table 3, multiple respondents have mentioned benefits related to Effort Expectancy.
Table 3: Themes Related to *Effort Expectancy* (based on data collected, available in Appendix 1)

<table>
<thead>
<tr>
<th>Number of Respondents</th>
<th>Ease of Use</th>
<th>Ease of Adaption</th>
<th>Technological Precision and Fit</th>
<th>Safe Around Humans</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>36</td>
<td>21</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

While the authors are aware that some of the data collected reflects the current state of cobot implementation within the companies studied, it can be argued that these companies had in fact such expectancies prior to the implementation. Also, these expectancies may have developed throughout the usage of the technology. Further, as the data is publicly available, it may shape *Effort Expectancy* of future users.

5.4 Social Influence

*Social Influence is defined as the degree to which someone feels like others deem it important for him or her to adopt and use the new system/technology.*

5.4.1 Users

One main challenge for the cobots to overcome, in regards to users/customers, is that the technology might not be well-known or not implemented within one’s respective network. As the results presented, one’s network was of great importance for the introduction to cobots. The empirical data gathered points towards the importance of word of mouth when it comes to the acceptance of cobots. This can be linked to the UTAUT model, where *Social Influences* within one’s network, can have a negative or positive impact on one’s behavioural intentions. If the cobot thus far has failed to be accepted within said networks, this can hinder the cobots growth potential, and the other way around. As previously mentioned, one of the main concerns regarding the development of robotics and cobots has been related to the potential decrease of human employment. While some have argued this to be a misconception, it can be related to a side of *Social Influence* that could potentially hinder the cobot’s path to acceptance. If someone reads about how robots will take over jobs, they might get worried and deem it important for him or her to not adopt this new technology. This concern for human employment has been brought forward in almost half of user case studies.
and, at the same time, refuted by the respondents after implementing cobots. In fact, in some cases, the implementation of cobots ultimately led to the hiring of more human workers.

Further, the data collected showed that many of the studied companies identified themselves with a technological and innovation driven organizational culture and philosophy. In these cases, workers may be more technology savvy and be more inclined to accept and use new systems. However, if the company culture has not been disseminated properly, there might be a gap between the management’s vision and the ability of employees to adapt. While *Social Influence* may have a role in making cobots more accepted within the workplace, it is important to realize that users, for instance workers, may be dependent on the decisions made by their managers to implement such technology. Therefore, the use of cobots may sometimes be involuntary and not be completely related to technology acceptance.

Table 4: Themes Related to *Social Influence* (based on data collected, available in Appendix 1)

<table>
<thead>
<tr>
<th>Culture and Organizational Philosophy</th>
<th>Concerns of Job</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Respondents</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

### 5.5 Facilitating conditions

*Facilitating Conditions refers to the extent to which an employee believes that an appropriate organizational and technical infrastructure has been put into place with the objective of supporting the use and adoption of the new system/technology.*

#### 5.5.1 Users

While cobots are argued to be easy to implement, program and use, some training and support seem to still be necessary for first time users. Companies implementing their first collaborative robot may not have experienced workers in the field, making the process potentially a bit more tedious. The data collected does not seem to reflect any organizational and technical infrastructure put into place by the companies implementing cobots within their
organization. However, *Facilitating Conditions* can be interpreted as also originating from an outsider source to the organization. In the case of first time user, companies producing cobots seem to usually offer demos and training sessions as part of their strategy. By doing so, and by helping companies find potential applications, companies producing cobots build *Facilitating Conditions* in order to make their technology more accepted within the customer's’ organization. As cobots are not yet fully accepted, professional guidance and user training seems to be important. User acceptance of cobots in the workplace appears to have increased through these learning processes as concerns were dissipated while benefits were highlighted. Finally, by offering continuous support through their after-sales strategy, cobot producer may have been able to reduce concerns about technical issues.

### 5.6 Government

Through the empirical findings the authors have tried to exemplify the role that a government can have on a product’s acceptance. Even though, the EU has started to publicly support the Cobot industry with a financial, safety and regulatory structure, filtering down from regional and national support to more multinational structures may take some time. As socio-economic and political ideologies filter down from government agencies, and then encourage people to act, it is possible that individual views on the increased usage of robots may not be positive. This could hinder the development of a regulatory and legal framework that would benefit the future development of the technology and growth of the industry. However, it could also be the other way around, with government officials that strongly support the Cobot industry manage to convey their vision upon others.

As described earlier, the EU has now realized that there is a need for new regulations and laws regarding the robotics industry. The development of cobots has pushed for new sets of rules and regulations as they involve direct interaction with humans, have the ability to adapt to their environment and can sometimes take their own decisions. As illustrated in the findings, the EU has started to commit resources, time and personnel in order to build an appropriate framework that will arguably not hinder the development of the industry, rather help encourage it. The EU’s official support to this industry can be deemed as a facilitator of *Social Influence* and provide *Facilitating Conditions*, which may result in further acceptance.
by other actors in the industry, as this can be perceived as a strong government body’s acceptance of the cobots. Further, as laws and regulations are developed, producers and users will have a clearer framework to relate to and get support from. One example brought forward was regarding the development of artificial intelligence. Robots now have more and more the ability to adapt to their environment and make their own decisions. Consequently, in case of an accident, it is important for users to know who is to blame. Having the appropriate regulatory and legal framework would lower this uncertainty. This can potentially lead these actors to feel more confident about accepting this type of products/technology. Thus, support from one actor in the industry has the potential to lead to further acceptance by other actors.

When a government body, like the EU, commits resources to develop a legal and regulatory framework for a new product/technology, it is likely that they do so by continuously learning more about this new technology to later create the relevant laws. As a technology enters the market and develops, new matters that need regulation might appear. Moreover, as different matters are addressed on a EU level, this may have the potential to foster learning and acceptance throughout the region. One example of this is, as the EU’s interest in robotics has grown, they have begun to fund different projects relating to this, for instance Robotics Week 2016 in Amsterdam.

As mentioned above, support by the EU can potentially lead to more acceptance by other actors in the industry. One of the main reasons behind this can be argued to be that it contributes to building trust towards cobots among its people. Thus, the government can play an important role in the process to cobot acceptance.
6. Conclusion

This chapter provides an overview of this thesis and its contributions to the IB research field. After summarizing the findings and theoretical contributions, study limitations and recommendations for future research are presented.

6.1 Findings and Theoretical Contribution

Collaborative robots have been brought forward as a potential mean to stay competitive in today’s increasing complexity of the IB scene. Cobots, with their easy and fast repro programmability, may also be a way for companies to become more competitive in the rising trend moving from mass-production to mass-customization. Cobots, as many new technologies, may first need to overcome certain factors that are impacting their acceptance as a new technology within a society.

Therefore, this thesis sets out to identify factors that may affect the acceptance of cobots and provide a more comprehensive overview of these. To achieve this, the following research question was formulated:

*What main factors can be said to affect the acceptance of cobots as a new technology?*

A conceptual framework was built in order to guide this study and categorize its findings. The collected data was grouped in accordance to the conceptual frameworks’ five variables: *Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions and Government Influence*. This study concludes that the main factors that can be said to affect cobot acceptance are the following, illustrated below in figure 4, presented earlier.
The collected data showed that companies’ decisions to adopt cobots seem to be influenced by *Performance Expectancy* of this new technology. With the demographic changes occurring in countries or regions, such as the EU, manufacturing companies are facing the challenge of a continuously aging and decreasing workforce. In order to maintain their performance and their competitive advantage in the new world of mass customization, cobots have been shown to be a reasonable solution. By providing companies with a wide array of possible applications at a relatively low cost, cobots seem to have impacted the operational gains of the companies that have implemented them. Cobots may not be suitable for every company as the technology may not provide the same expected performance. In fact, it was shown that some companies have yet to see the right applications or usefulness of the technology.

*Effort Expectancy* was found to be another variable potentially affecting cobot acceptance. Companies have expressed their unwillingness to adopt a technology that would be deemed too difficult or demanding to implement and use. The gathered data has shown that *Effort*
Expectancy may be influenced by factors closely related to the cobot itself, but also how an individual perceives it. As cobots are made to work alongside humans, workers have to feel constantly safe in order to reduce effort, which is why safety standards have been established to be an important factor. Safety has also been linked to the cobot’s appearance and movement as, if too human-like, seem to make workers uncomfortable. Further, acceptance may be influenced by user experience as cobots seem to be marketed as easy to use and implement. In regards to this, the data seem to show that workers, sometimes sceptical at first, agreed that it was easy to learn how to use cobot after being taught.

In regards to Social Influence, it was shown that most companies had heard about collaborative robots through their networks and contacts. Thus, acceptance within a network and the experiences within this network, can have a crucial role for the acceptance of cobots. Further, company culture seemed to have an impact on acceptance as companies identifying themselves as interested in new technologies had opted cobots. In fact, such companies may employ workers with strong technical knowledge, and eagerness to use new technologies, making the implementation easier. Further, the general perceived negative impact on employment seemed to be a barrier to acceptance as it can influence one’s opinion, making workers worried about losing their jobs. However, it was shown that cobots are not meant to reduce human employment but to be used as a tool for human workers instead. After implementation, this seemed to be confirmed as workers expressed their satisfaction from using a cobot. By expressing their support of the technology, the EU impacted cobot acceptance through Social Influence. Finally, the data has shown that producers tend to provide certain Facilitating Conditions to their customers in order to positively impact acceptance, such as on-site demos and training sessions. In addition, it was also shown that the EU seem to have an impact on acceptance through Facilitating Conditions, such as financing and funding. The EU’s support can be argued to facilitate acceptance in the region in general, however, not necessarily within the framework of this thesis.

The findings of this study reinforce existing literature on technology acceptance in that a newer technology can face obstacles when gaining acceptance. This thesis contributes to the theoretical literature by providing a more extensive overview of factors that can be said to impact cobot acceptance and spread. In addition, this study adds to previous research by
illustrating the potential effect a government can have on cobot acceptance. Considering government influence as a factor of cobot acceptance is, to the best of our knowledge, novel and may contribute to the development of future research within the field. By providing an overview of potential factors affecting cobot acceptance, the authors are set to contribute by building a base for future research within the field.

6.2 Study Limitations and Recommendations For Future Research

Although this thesis contributes to a more comprehensive overview of factors that can affect cobot acceptance, some limitations have to be taken into considerations as emphasized in chapter 3. These limitations can, however, also provide opportunities for future research. Firstly, since this study used secondary data as it source for analysis, it may be of interest to collect primary data in order to dig deeper into some of the factors brought forward by this study. The use of secondary data has been a source of limitations to the study as it has its set of disadvantages, as previously described in chapter 3. One of these limitations that were realized when collecting the data was that the authors could not impact how up to date these publications were. While this study contributed with a more comprehensive overview, it could be beneficial to strengthen the findings with more recent sources. Moreover, as the collaborative robotics field is relatively new and unexplored, especially from an IB perspective, there is more to be done within the field. For example, an analysis of other aspects, such as cultural influences on technology acceptance within this industry, would be interesting.
7. References


# 8. Appendix

## Appendix 1: Users/Customer Case Studies

<table>
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<tr>
<th>No.</th>
<th>Company</th>
<th>Country</th>
<th>Industry</th>
<th>Ease of Use</th>
<th>Ease of Adaptation</th>
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<th>ROI</th>
<th>Improved quality of product</th>
<th>Improved cycle time</th>
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