A Study of the Adoption of Internet of Things Among German Consumers

Bastian Leonard Thiel

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ABSTRACT

Background/Purpose: Recently, Internet of Things (IoT) technology got an increased amount of attention from private consumers. Based on this increased attention, IoT companies start to become more interested in entering the private consumer market. However, there is a gap between the predicted and actual adoption of IoT technology. In addition, research on this topic in the country context of Germany is scarce. The purpose of this research is to fill that gap and identify factors that determine the intention to adopt IoT technology among German consumers. IoT companies can use these findings to better market their products.

Methods: The researcher of this thesis proposes an extended technology acceptance model (TAM). Linear and multiple regression analysis were employed to test the proposed hypotheses with data from 158 German potential consumers of IoT technology.

Findings: The results indicate that trust has a particular strong effect on the intention to adopt IoT technology in Germany. Besides, the three additional factors, perceived usefulness, social influence, and perceived ease of use, were also found to be statistically relevant. Extending the traditional TAM model resulted in a high explanatory power about why potential consumers intent to adopt IoT technology.

Originality: The created framework researches determinants of the intention to adopt IoT technology from the consumer perspective instead of an organisational one as several previous researches did. This thesis successfully links and extends the constructs of trust and social influence to the classic TAM in an IoT technology context.

Keywords: Internet of Things, Information System, Innovation Adoption Behaviour, Intention to Adopt, Technology Acceptance Model, Trust, Social Influence, Perceived Usefulness, Perceived Ease of Use

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List of Abbreviations

BI	Behavioural Intention
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
IoT	Internet of Things
IT	Information Technology
ITU	International Telecommunication Union
RFID	Radio-Frequency Identification
SN	Subjective Norm
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
VIF	Variance Inflation Factor

1. Introduction

1.1 Research Background

The last decades showed rapid technological developments. Businesses have fallen and emerged, new forms of communication were established, and the way consumers purchase and adopt has changed. By now, technology is an essential part in the life of consumers. A term that is oftentimes mentioned when speaking of this context is Internet of Things (IoT). These “interconnected physical objects, capable of sharing data about their state or the state of their environment” (Yonck, 2013, p. 17) originally derived from the radio-frequency identification (RFID) technology. Since the 1990s, businesses use RFID to track product inventory, facilitate access to buildings, or collect health data. Nowadays, this kind of technology found its way also into many private households. In 2018, the global IoT market was expected to be worth $23.14bn and 7.5 per cent of private households were expected to own connected devices. It is estimated that the rapid growth of this market will continue. By 2022, the market value will reach $42.62bn while almost every fifth household (19.5 per cent) will own IoT devices. Similarly, revenues from IoT devices are predicted to grow annually by 25.8 per cent between 2018 and 2022 from $48,710m to €121,960m (Statista, 2018b, 2018a). Based on these numbers, the IoT market can be considered a promising business opportunity. There is a multiplicity of fields of application for IoT devices and they have the power to not only change lives but also potentially change the world (Gao & Bai, 2014; Manyika et al., 2015). Current examples in the private consumer market include adapting room lightning by giving voice commands to an Amazon Echo (Philips Hue, 2018), pre-heating the living room from anywhere with the Google Nest technology (Nest, 2018b), or detecting potential heart irregularities with an Apple Watch (Goode, 2018). There is a plurality of additional fields in which IoT devices can be implemented such as “environmental monitoring, health care, inventory and product management, smart home and workplace, [and] security and surveillance” (Atzori, Iera, & Morabito, 2014, p. 97).

In order to do all of this, IoT devices require to continuously collect and process data. On the one hand, this data can be used by brands and the devices itself to further

improve the user experience. For instance, a fitness tracker that monitors its user's sleep can use this data to identify sleep patterns (Broughall, 2014). Based on these patterns, the fitness tracker communicates with a connected alarm clock to automatically set an alarm that wakes the user at the best time according to his or her body's natural sleep circle. Accordingly, the quality of sleep is improved by technology. Further, this example shows that users can experience the biggest benefits when there is a plurality of IoT devices in a household and they freely communicate as well as exchange data with each other. Nevertheless, the real value of IoT devices does not result from consumers having the ability to make settings in a convenient way but from IoT devices using individual user data to identify consumer preferences and acting accordingly on their own without any user involvement at all. Through such personalisation and superior user experience, the connection between brand and user becomes both stronger and more personal.

On the other hand, collecting data can be seen as a potential security issue as IoT devices may use unencrypted networks or allow simple passwords (Y. K. Lee, Batina, & Verbauwhede, 2010). Hackers could use such poorly secured IoT devices as a gateway to access payment methods of private users or gain access to a company network with classified data. If such a high-profile hack is covered by the media, potential customers may be deterred from purchasing such devices. This is supported by a study of Accenture (2016) among 28,000 consumers in 28 countries that identified privacy and security issues as the second highest barrier to adopting IoT devices and services (47 per cent) after price (62 per cent). Though, it is not only hackers that consumers are concerned about but also the ones who collect the data, namely companies and governments (Mani & Chouk, 2017; Medaglia & Serbanati, 2010). Some consumers may see IoT technology as mostly beneficial, but others may consider it to be potentially harming. Against this background, it becomes evident that it is of the utmost importance for IoT companies to understand how potential and actual IoT consumers in differing markets make their adoption decisions in order to eliminate adoption barriers and promote adoption benefits. Only then can companies make use of the full potential of the IoT market.

1.2 Problem Statement and Research Questions

Despite the promising business potential of the IoT market and the outlook that a rising number of private households, and thus end consumers, will own and be in direct contact with IoT devices in the near future, some market analysts state that the growth estimations of the IoT market may still lie below the full potential (Manyika et al., 2015). Although the IoT market already reached a sizable volume, the future outlook is what makes this market extremely attractive for established and new entrants as well as locally or globally active companies. Those who are able to exploit this opportunity the best will also significantly benefit from it. However, capitalising on the opportunity requires more than merely having a good product. Beyond, an adequate communication strategy is necessary to convince consumers to adopt from a given company instead of from competitors. There are no two markets that are the same which is why it is not simply possible to apply knowledge of one market to another one. Consumers in differing markets also have differing needs and concerns. An example for what happens when a company fails to address adoption needs in differing markets is Jawbone. Their fitness trackers were one of the first on the market, performed well in tests (Broughall, 2014), and got several high investments from venture capitalists (Sommerville, 2017). The company and its products were expected to be a dominant player in the wearables market for the coming years. Instead, Jawbone made history as one of the largest failures among venture-backed businesses because they had burnt through all of their $900m of investments and ultimately had to give up the business in 2017 (Sommerville, 2017). Jawbone should be a cautionary example for other players in a market that is as quickly changing as technology develops.

Consumers have never been more informed about IoT products than today. Google trends shows an increase by 50 per cent in the search term ‘Internet of Things’ between 2015 and 2018 (Google Trends, 2018). On the one hand, the enlarged interest in this technology shows that consumers are getting increasingly aware of IoT products. A reason for that may be that considerable companies such as Amazon, Apple, or Google entered the market. Their product launches or integration in well-established products oftentimes result in an amplified media coverage which raises consumer interest (Olenski, 2014). On the other hand, this also means that consumers are also increasingly informed about it. The information consumers obtain are not exclusively

favourable but can also be derogatory. Potential consumers learn about the benefits but also about faults and issues that IoT technology still has to struggle with.

The private end consumer IoT market may still be relatively young but the increased consumer interest shows that the market is currently maturing. However, consumers informing themselves about IoT technology does not necessarily mean that they also purchase and adopt it. The novelty of private IoT applications still means that companies have to deal with adaptation issues just as with any other technologies before (Gao & Bai, 2014; Luukkonen et al., 2016).

There has been a great amount of literature on the field of information technology (IT) acceptance (Venkatesh, Thong, & Xu, 2012) in various contexts. Technology acceptance and adoption were identified as major indicators of purchase intention (Taherdoost, 2018) and actual usage (Taherdoost, 2018; Yi, Jackson, Park, & Probst, 2006). Several models have been developed to research technology acceptance and adoption (Taherdoost, 2018). Notwithstanding the attractive opportunity of the IoT market for businesses, previous studies have only focused on the American or Asian markets (Chang, Dong, & Sun, 2014; Gao & Bai, 2014; Liew et al., 2017) and neglected the European one.

Moreover, the acceptance and adoption of previous technological innovations that defined single categories of products (e.g. the evolution of smartphones) are hardly comparable to the development of IoT that is about to have an impact on and change an entire range of products (Dormehl, 2014). IoT must not be seen as an technological evolution but rather as the start of a new technological revolution (Alarcon, 2015; Lu, Papagiannidis, & Alamanos, 2018). It is different from previous technological innovations because it is as integrated into everyday life as no other technology before. Companies ask consumers to trust IoT devices with some of the most private aspects of their life such as the security of their homes or personal health data. Additionally, such devices are much more difficult to grasp for consumers because they perfectly blend in (e.g. sensors) and are almost indistinguishable from their surroundings (Dormehl, 2014).

The previous discussion showed that the IoT market can be a promising business opportunity for established companies as well as potential new entrants but also a challenge if not researched thoroughly. Even well-established companies like Amazon and Jawbone struggle or fail as consumers remain sceptical because of issues such as cyber security. As previous literature has not researched the adoption of IoT products in an European context, this master thesis aims to contribute to filling that gap.

In particular, the aim of this thesis is to research **which determinants influence the intention to adopt IoT technology and to what extent**. From a managerial perspective, identifying key drivers of IoT adoption could result in notable implications to market IoT products and services in a more effective manner. The theoretical and practical insights resulting from the research can be implemented in IoT marketing and communication. Especially for globally active companies from outsight of Europe, their locally established strategy may not be transferable to this new market. It could be the case that European consumers attach much more importance to different attributes in comparison to consumers outside of Europe. Researching which determinants influence the intention to adopt of European consumers is crucial to be successful in this market and make use of the full potential of the IoT market. Insights from this thesis are valuable for all companies because they either create or deepen the knowledge about this market. Such knowledge can be used to create a suitable communication strategy underlining the most impactful benefits of IoT devices and levering the concerns of consumers. Thus, it is the foundation to successfully introduce new products in the market or increase the adoption of established ones.

Therefore, the following research questions are raised to be answered:

- How is the consumer adoption of IoT technology and services influenced?
- Which antecedents positively and negatively influence the intention to adopt IoT technology?

1.3 Project Structure

The previously outlined objectives and the research questions will be answered within the following sequence. Following the introduction chapter, **chapter two** will elaborate on the methodology of this project. Within this chapter, the methodological positioning of the researcher as well as the chosen research approach will be explained. Additionally, the methodology belonging to the systematic literature review will be presented and which steps have been taken in order to select the literature. The chapter will end by stating the research design, depicting the data collection and analysis method, as well as describing how and what quality criteria were applied.

Within **chapter three**, a comprehensive systematic literature review will be presented. Results from said literature review will be the basis for a conceptual and several hypotheses.

Subsequently, **chapter four** will present the core of this thesis by presenting and analysing the findings of the thesis. The collected data will be used to test the proposed hypotheses.

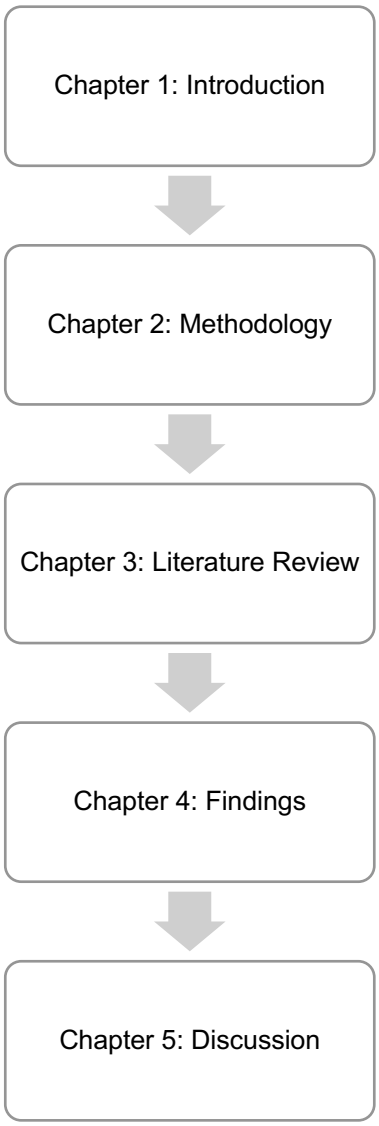

Figure 1: Project Structure

Finally, **chapter five** will discuss the results and put them into a practical context within the managerial implications. The chapter will end with limitations and ideas for future research opportunities.

2. Methodology

In the following chapter, the various methodological considerations which arise in the course of a scientific research will be laid down. Hence, this chapter formulates the research plan and will guide the entire master thesis. The following sections examine the researcher's stance on philosophy of science, the literature review method, research design, research method, data collection method, data analysis method, as well as quality criteria.

2.1 Methodological Viewpoint

It is crucial to touch upon the philosophical assumptions to comprehend the researcher's view on reality as well as the methodological choices for examining the given phenomenon (Bryman & Bell, 2011; Kuada, 2012). The entirety of assumptions which guide a study make up various paradigms. Hence, a paradigm describes "a cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done, [and] how results should be interpreted" (Bryman, 1988, p. 4). Since the methodological viewpoint has an impact on the entire research process and represent the researcher's view about the studied objects, it is important to depict it in detail (Kuada, 2012; Saunders, Lewis, & Thornhill, 2009). Burrell and Morgan (1979) originally developed four root assumptions, namely ontology, epistemology, human nature and methodology, which underlie each paradigm. All the named assumptions hold dispositions that are either subjectivist or objectivist. In the following, the two main philosophical considerations, ontology and epistemology, are discussed with regards to the objective-subjective model. By this means, it is aimed at connecting the research questions with the research activities and unveil the researches underlying paradigm.

2.1.1 Ontology & Epistemology

Ontology describes the philosophical "study of being" (Crotty, 1998, p. 10). As such, it is concerned with "the nature of what the researcher seeks to know" (Kuada, 2012, p. 58) and the researcher's perception of reality. With respect to the objectivist-

subjectivist model by Burrell and Morgan (1979), one can distinguish between two philosophical positions regarding ontology: realism and nominalism. Realism understands reality to exist external to the individual. Conversely, nominalism implies that reality is “the product of individual cognition” (Burrell & Morgan, 1979, p. 1) and is hence subjective and individually constructed (Kuada, 2012).

The research at hand, first, aims to uncover the diverse determinants of the intention to adopt IoT technology and, secondly, objectively tests and verifies the uncovered determinants in a German country context. Companies offering IoT technology are considered external entities with an own reality. People that adopt the products do not shape this reality. A company presents its products and services in an attractive way which manifests in consumer interest and thus an intention to adopt. Furthermore, when several companies follow this strategy, a synergy effect will be created that increases the effect. Nevertheless, there are always external factors (i.e. the ‘human factor’) that make it impossible to state that a study is entirely objective. While an individual nowadays has manifold opportunities to spread his or her opinion with a company, a company will most likely still continue according to how it was planned. Thus, this research assumes a single, given reality which exists independent of the individual cognition. Exhibiting a predominantly objectivist conception of social reality, this study takes a realist stance regarding ontology (Bryman & Bell, 2011; Kuada, 2012).

Epistemology deals with the theory of knowledge and addresses “the nature of knowledge and the means of knowing” (Kuada, 2012, p. 59). Against the background of the objectivist-subjectivist distinction, the researcher needs to decide if knowledge and meaning is a fixed construct that can be best understood through external observation (positivism) or if it is constructed, so produced through personal exposure, and is best studied in an intersubjective manner (antipositivism) (Burrell & Morgan, 1979; Crotty, 1998; Kuada, 2012).

The researcher of the present study regards knowledge and meaning as fixed and wants to uncover reality as it exists by means of a scientific approach and of positivism in particular. This indicates that the researcher considers himself independent of what is being researched and that any external researcher has the possibility to conduct the

same investigation and uncover the same truth (Kuada, 2012). Overall, the researcher's aim is to comprehend a fraction of the social world to thereby understand and explain the whole social world (Bryman & Bell, 2011; Kuada, 2012). Thus, the researcher seeks to understand reality with a focus on regularities, analogies and causal relationships (Kuada, 2012).

2.2 Methodological Outline of the Systematic Literature Review

As a theoretical foundation of a research, the literature review comprehensively informs about the investigated research area, gives a current picture of the research in field and uncovers research gaps. Accordingly, a relevant and well-informed academic project demands for a thorough and attentive study of prior researches (Danson & Arshad, 2014; Kuada, 2012; Webster & Watson, 2016).

The study at hand adopts a systematic review approach. The systematic literature review is a type of literature review that uses systematic methods to collect, critically appraise and synthesise all available literature relevant to a particular research question (Danson & Arshad, 2014). Against this background, this type of literature review is a very rigorous and transparent form of literature review which is designed to provide a complete, exhaustive summary of current research in the field.

Regarding the research at hand, a systematic literature review is regarded well-suited since it is crucial to this research to unveil all of the prior literature on this rather focused research question within this new field of study. In addition, the before stated methodological positioning dictates objectivity in the entire research process. The systematic literature review is particularly qualified in that respect as its fixed, protocol alike process promotes transparency and minimises the effect of selection, publication and data extraction bias (Kuada, 2012). As a result of this objective, transparent, and rigorous approach, systematic literature reviews ensure future replicability. Nevertheless, this exhaustive approach of reviewing the literature also makes it a very resource-intensive process (Bryman & Bell, 2011; Danson & Arshad, 2014; Jesson, Matheson, & Lacey, 2011).

The following sections will carefully outline the methodological steps that were taken to attain the final literature review, presented in Chapter 3.

2.2.1 Search Scope and Search Strategy

There are several different search techniques which are commonly used when identifying references for a systematic literature review. Papaioannou, Sutton, Carroll, Booth & Wong (2009) mention five search techniques: conventional subject searching, citation searching (also forward searching), reference list checking (also backward searching), comprehensive pearl growing and contact with experts. Literature suggest to adopt several of the mentioned techniques in the search process in order to ensure that all relevant references are found (Papaioannou et al., 2009; Petticrew & Roberts, 2006). The present research uses conventional subject searching as a primary search technique and complements it with forward and backward searching as supplementary search techniques.

To develop an adequate search string for the conventional subject search, preliminary identified references were screened in an unstructured manner regarding pertinent key terms in relation to the investigated subject. Hereby, both English as well as German references were taken into consideration, as the author is native German. In a next step, the key terms were mapped via ‘Thesaurus’ to further include applicable synonyms. Lastly, the key terms were assembled in a search string with the help of Boolean search operators. The ultimate search string that was applied to the selected databases looked as follows:

> ("Internet of Things" OR "IoT" OR "Internet der Dinge" OR "smart home" OR "smart technology") AND ("adoption" OR "intent to adopt" OR "intention to adopt")

The chosen databases for the literature search were Proquest, Ebsco, Scopus, Science Direct and Emerald Insight. The primary argument for selecting those databases lies with the great number of covered records as well as being multidisciplinary (Aalborg University Library, 2018). By searching all those databases, the researcher hopes to uncover all potential references and ensure the quality of the overall research. In the following, the specific limiting criteria will be outlined.

2.2.2 Search Criteria and the Selection Procedure

The applied inclusion and exclusion criteria constitute limiting criteria which inherently set the review's scope. The limiting criteria of this research were established prior the literature search and selection process to secure the research objectivity.
For the conventional subject search, the search was carried out with a limitation to only include references where the search terms appeared in the title, keyword, or abstract for instance. In this way it was made sure that all references fulfilling the conditions of the search string, hence all references relevant to the investigated subject, would be included. Consequently, the conventional subject search of all databases resulted in a total number of 6,938 references, prior applying inclusion and exclusion criteria.
The first inclusion criterion was set on the publication language. Since the researcher of this thesis is, as previously mentioned, native German and fluent in English, the included references needed to be published in either of these languages. Besides the search criterion regarding the publication language, the publication titles needed to qualify as peer-reviewed to be included. By adding this qualitative filter, the researcher attempted to ensure the quality of the included references and hence the validity and reliability of the overall literature review.

After applying the search criteria to the search results of the conventional subject search, the duplicates between the search results of the different databases were removed. Resulting from the application of the search criteria as well as the de-duplication, 1,043 references were subjected to closer review.

Following, the references were stepwise evaluated. Firstly, the references were sifted concerning title, keyword, and abstract and deselected if they did not show sufficient relevance regarding the investigated subject. In the second step, the remaining references were subjected to a full text sift and it was again decided upon the relevance of the article to the researched problem of this thesis. This resulted in 35 unique references, which were assessed eligible for data synthesis.

Lastly, the 35 selected references were searched backwards and forwards to guarantee that really all relevant pieces of literature are comprised in the literature review. Resulting from this, another 17 references were identified and added to the

reference list. As such, the total number of 52 references were used for the following data synthesis. An overview of the literature selection process is provided in Appendix 1. In addition, Appendix 2 offers an example of the literature data base.

In general, it needs to be noticed that the reference search with the adopted conventional subject search put forth only a relatively little number of hits for a systematic literature review. This can probably be ascribed to the nascent stage of the research area which can also be seen in the publication dates of the selected references. As such, the oldest reference that was selected for data synthesis is dated to the year 2002. Moreover, while reviewing and selecting the different references, the researcher got the impression that most of the research on the subject derives from Asia or the United States, however only few of the references were stemming from or covering the country context Germany.

2.2.3 Data Synthesis Process

In the data synthesis of a literature review, the various forms of evidence, retrieved from the reviewed literature, are combined to ‘a new whole’ (Pope, Mays, & Popay, 2007). While doing so, a researcher can choose from different synthesising methods. Broadly, one can distinguish between integrative and interpretive synthesis methods (Noblit & Hare, 1988). The literature review at hand draws on an integrative synthesis method. The reason for this is that it is assessed most fitting regarding the investigated subject and the research’s objective as it summarises and amalgamates the extracted findings with the goal to provide a comprehensive overview (Dixon-Woods, Agarwal, Jones, Young, & Sutton, 2005). Furthermore, an integrative synthesis better reflects the researcher’s methodological viewpoints, which were set out before. Among the different integrative synthesis methods, a narrative synthesis was adopted. A narrative synthesis is particularly advantageous as it is characterised by being very flexible regarding different research and evidence types. As such, a narrative synthesis has the ability to process both qualitative as well as quantitative evidence (Dixon-Woods et al., 2005; Pope et al., 2007; Snilstveit, Oliver, & Vojtkova, 2012). Lastly, a narrative synthesis has proven sensible when employing a systematic review as done within this thesis (Dixon-Woods et al., 2005).

2.3 Research Approach

In the present research the approach to the relationship between theory and research is deductive. As such, theory builds the basis of the study and guides the research, which is why the deductive research approach is also referred to as 'theory-then-research strategy' (Saunders et al., 2009). In accordance with the characteristics of a deductive approach, this study aims to answer research questions and test hypotheses that derive from theoretical concerns. The process of deducing is a linear series of steps, moving from theory over data collection and analysis towards conclusions (confirming or rejecting the hypotheses). Regarding the data collection, the deductive approach typically draws on a quantitative research method (Bryman & Bell, 2011), as also done in this study (see Chapter 2.5: Research Method).

The methodology of the deductive research approach is highly structured, which ensures validity, reliability, and replicability (Gill & Johnson, 2002). Similarly, generalisability is a quality of deduction, however for the findings to be sufficient it requires a large sample size (Saunders et al., 2009). Lastly, the deductive research approach is the most commonly used in business research and has proven reliable (Bryman & Bell, 2011).

2.4 Research Design

The research design represents the guiding plan for the entire research and structures every step of a study, from data collection to data analysis (Bryman & Bell, 2011; De Vaus, 2001; Kumar, 2011; Saunders et al., 2009). It aims at joining the various research elements in a way that approaches the research problem most efficiently (De Vaus, 2001). Besides the different processes and action steps of a research study, the research design also reflects on the quality within the action steps, also designated as design quality. Regarding quantitative research, such as the one presented here, the most prevalent quality criteria for the assessment of scientific research are validity, reliability and replication (Bryman & Bell, 2011; Kumar, 2011).

The research at hand adopts a cross-sectional design, also referred to as social survey design (Bryman & Bell, 2011) which deductive research oftentimes does as well. "A

cross-sectional design entails the collection of data on more than one case [...] and at a single point in time in order to collect a body of quantitative or quantifiable data in connection with two or more variables [...], which are then examined to detect patterns of association" (Bryman & Bell, 2011, p. 53). Hence, a cross-sectional design examines relationships between variables through which it can identify a certain phenomenon or correlation. Having said this, it needs to be noted that a single cross-sectional design cannot measure change nor determine causality as it only takes a cross-section of one specific point in time. This typically results in a weak internal validity (Bryman & Bell, 2011; Kumar, 2011).

The advantages of a cross-sectional research design lie in the data collection and data analysis. The study population only needs to be contacted once, which makes the data collection comparatively easy. As for the data analysis, several statistical tools are available to make the analysis process relatively simple and straightforward. Overall, this leads to a low resource cost and makes this kind of research design very applicable to the confined limitations of a student research (Kumar, 2011).

2.5 Research Method

In general, information is either collected by means of qualitative or quantitative methods. While it initially seems that they are distinctive from each other, Creswell (2014, p. 3) states that they should be rather seen as "different ends on a continuum". Nevertheless, it is suggested in the literature that qualitative and quantitative methods are oftentimes associated with certain philosophical assumptions and positions in regard to the role of theory (Bryman & Bell, 2011; Creswell, 2014).

Research applying qualitative methods usually focusses on words instead of numbers while adopting an inductive approach which emphasises theory building. Moreover, researchers that adopt qualitative methods put much attention on the interpretation of what data means. Therefore, qualitative research aims to explain how entity is created by the interaction of various elements. This means that participants of the research are observed within their usual environment and that the researcher needs to be a part of this environment when researching the phenomenon (Bryman & Bell, 2011; Creswell, 2014; Kuada, 2012).

In contrast to that, quantitative research focusses on quantification and favours numbers over words. The research is commonly approached deductively and instruments as well as statistical procedures are utilised for theory testing. While researching, the researcher is ought to be neutral in order to minimise his or her own influence on the participants. The quantitative approach is usually connected to a positivistic positioning and holds the view that the social reality exists independently from the individual (Bryman & Bell, 2011; Creswell, 2014; Kuada, 2012).

Decisive factors in choosing how to obtain data are the research objective as well as the resources available to the researcher (Kumar, 2011; Zikmund, 2003). Having both the aim of the research and the available resources in mind, the researcher of this thesis chose to collect primary data by applying a quantitative research method. Resulting from the choice to follow a quantitative research method and a deductive research approach, the techniques to collect data are limited (Bryman & Bell, 2011). The researcher of this thesis chose to acquire data by a single data collection method which Saunders et al. (2009) refer to as monomethod-quantitative study. Several reasons support this decision. First, this thesis aims to research and understand differences between several variables. Such variables can be measured easily when clearly defined. The determinants of perceived usefulness (PU), perceived ease of use (PEOU), social influence, and trust are concepts that can be determined easily and clear. Accordingly, the literature was reviewed in a structured manner which enabled the researcher to form hypotheses that meet the research objective. Saunders et al. (2009) refer to this approach as deductive theory testing. This approach is commonly applied in quantitative research to investigate the link between theory and research. Furthermore, it was previously mentioned that quantitative research is oftentimes connected to a positivist approach. This thesis does this as well because the quantitative approach enables the researcher to research the phenomenon from the outside and in a natural research setting (Kuada, 2012). By doing so, the research at hand aims to identify determinants of the intention to adopt IoT technology in Germany. Additionally, this approach of conducting the research serves an explanatory purpose as it aims to explain how the intention to adopt IoT technology is determined by the variables of PU, PEOU, social influence, as well as trust (Saunders et al., 2009).

A survey design enabled the researcher of this thesis to collect data. The survey design is a frequently used tool to collect quantitative data and quantify the relationships between variables with the goal to collect a large amount of data in order to answer specific research questions (Saunders et al., 2009). In particular, a researcher can choose between three commonly used forms of a survey which are self-completion questionnaires, structured interviews, and structured observations. Additionally, it is possible to further break down the self-completion questionnaires by how participants answer. One option is that participants have to send the finished questionnaire back after initially receiving it via email or post. Another option is that it is entirely received, filled out, and send back via the web. The researcher of this thesis opted for this option of a self-administered online web survey and there are several reasons for that (Bryman & Bell, 2011; Saunders et al., 2009). To begin with, it is an inexpensive and efficient possibility to generate a relatively large data set in a short period of time. Using a self-completion questionnaire additionally enables the researcher to eliminate the interviewer effect. One great advantage for the participants of the study is they can fill out the questionnaire whenever they feel most comfortable and take their time to understand the questions. Moreover, it can be ensured that the participant does not know the entire questionnaire from the beginning by only showing a certain amount of questions per page. Lastly, the researcher benefits from the complimentary online tools of the questionnaire that processes the data immediately and enables to check data while it is still being collected (Bryman & Bell, 2011; Saunders et al., 2009). Nevertheless, there are also risks that come with the choice of a self-completed online questionnaire. For instance, no person is present to explain and guide participants about the understanding and answering of the questions. Accordingly, questions need to be designed carefully and it is recommended to avoid long or complicated ones, as well as too many open ones. Otherwise, this could lead to a low response rate or a lot of incomplete questionnaires because people get bored and abort or rush through the questionnaire. Another point of criticism is that there is no possibility to check whether the receiver and the actual participant of the questionnaire are the same person. It can additionally occur that some are more likely to answer the questionnaire than others. Consequently, results could be biased because it is not possible to ensure that participants are homogeneous to non-participants (Bryman & Bell, 2011; Saunders et al., 2009).

The researcher of this thesis is aware of these disadvantages which enables him to take actions in order to react to them. The following chapter is dedicated to developing the questionnaire and describes some measures that were taken to counteract the previously mentioned risks.

2.6 Operationalisation

Operationalisation describes the process of developing and defining measures for a certain concept or phenomenon (Bryman & Bell, 2011). To do so, the investigated concept is broken down, or itemised, into precise and viable entities (Saunders et al., 2009). Along with the applied research method, those operational entities can consequently properly measure the investigated concept. A precise operationalisation will guarantee the clarity of concept definition, support the questionnaire development and hence improve the concept's correct measurement. Moreover, it increases transparency and supports replicability, so that other researchers have the chance to build upon the research at hand.

In Table 1 below, the research's central concepts are operationalised, which is also in line with the developed survey (see Appendices 3 and 4).

Concept	*Item*	*Statement*	*Source*
Perceived usefulness	PU1	IoT technology will be useful in my daily life.	(Gao & Bai, 2014; I. Lee, Choi, Kim, & Hong, 2007; Mathieson, 1991; Mital, Choudhary, Chang, Papa, & Pani, 2016)
	PU2	Using IoT technology will reduce the effort required in accomplishing my daily activities.	(Mathieson, 1991; Mital et al., 2016)
	PU3	IoT technology will make it easier for me to do my daily activities.	(Gao & Bai, 2014; Mathieson, 1991; Mital et al., 2016)
	PU4	IoT technology will improve my performance of daily activities.	(Gao & Bai, 2014; Mathieson, 1991; Mital et al., 2016)
	PU5	IoT technology will make me accomplish my daily activities more quickly.	(Gao & Bai, 2014; I. Lee et al., 2007;

			Mathieson, 1991; Mital et al., 2016)
Perceived ease of use	PEOU1	I am able to operate IoT technology.	(Mathieson, 1991; Mital et al., 2016)
	PEOU2	IoT technology requires a lot of mental effort.	(Gao & Bai, 2014; I. Lee et al., 2007; Mathieson, 1991; Mital et al., 2016)
	PEOU3	Accessing IoT technology is convenient.	(Mathieson, 1991; Mital et al., 2016)
	PEOU4	IoT technology is clear to use.	(Gao & Bai, 2014; Mathieson, 1991; Mital et al., 2016)
	PEOU5	IoT technology is easy to use.	(Gao & Bai, 2014; I. Lee et al., 2007; Mathieson, 1991; Mital et al., 2016)
Trust	T1	IoT technology is trustworthy.	(Gao & Bai, 2014)
	T2	IoT technology providers keep their promises and commitments.	(Gao & Bai, 2014; Yang, Lee, & Zo, 2017)
	T3	IoT technology provider keep my best interests in mind.	(Gao & Bai, 2014; Yang et al., 2017)
	T4	IoT technology provides reliable information.	(Gao & Bai, 2014)
Social influence	S1	The decision to use IoT technology is because my friends encourage the use of IoT technology.	(Madden, Ellen, & Ajzen, 1992; Mital et al., 2016)
	S2	The decision to use IoT technology is because the media encourage the use of IoT technology.	(Madden et al., 1992; Mital et al., 2016)
	S3	The decision to use IoT technology is because my family encourage the use of IoT technology.	(Madden et al., 1992; Mital et al., 2016)
Intention to adopt	IA1	I expect to use IoT technology in the near future.	(Gao & Bai, 2014; Mital et al., 2016; Yang et al., 2017)
	IA2	I intend to use IoT technology in the near future.	(Gao & Bai, 2014; Mital et al., 2016; Yang et al., 2017)
	IA3	I am determined to use IoT technology soon.	(Gao & Bai, 2014; Mital et al., 2016)

Table 1: Operationalisation Table

2.7 Survey Development

By following a clear structure, the researcher of this thesis aimed to ensure that the response rate is as high as possible and the data is both reliable and valid. The survey development is based on suggestions and recommendations of Saunders et al. (2009). Taking the problem formulation as a starting point, the first step was to design aims and objectives of this thesis (1). Afterwards, the individual questions that can help to answer them were developed (2). In a third step, these questions were structured and positioned in a logical order (3). Once this was completed, the entire questionnaire was translated into German (4). In the fifth step, the layout of the questionnaire was designed (5). After pre-testing the questionnaire (6), it was planned how the questionnaire was to be administered and executed (7). Online tools such as the chosen 'SurveyXact' were not only useful for the developing and designing of the questionnaire but also for the handling of the questionnaire (i.e. collecting, entering, and analysing the data) (Saunders et al., 2009). To see the final survey in German or English see Appendices 3 or 4 respectively.

(1) Collecting necessary information for theory testing

Before a survey can be created, it is important to collect the necessary information needed to test the constructed hypotheses. Doing this is vital because once the questionnaire is sent out, there is no additional opportunity to contact the participants again in order to get additional data. The developed concept, that is based on the literature review, revealed that five variables are to be researched: four independent ones (PU, PEOU, social influence, and trust) and one dependent one (intention to adopt). All elements and measurements of them were taken from the literature. Since it was of interest to research how participants felt about the different constructs, opinion variables were used to measure PU, PEOU, social influence and trust. As the intention to adopt is something that participants would carry out, behavioural variables were used to measure this (Saunders et al., 2009).

(2) Designing individual questions

Individual questions needed to be formulated in order to research the previously mentioned variables. Bryman & Bell (2011) state that a researcher can support participants in understanding the questions and thus giving more decisive answers by accurately defining the questions before sending the questionnaire out. The researcher of this thesis based the chosen questions on questions and findings from other research with similar contexts that were identified during the literature review. By doing so, several indicators were identified to measure the concepts of PU, PEOU, social influence, trust, and intention to adopt. Ultimately, the multiple indicators were used to form composite variables in order to measure the overall factor. Using and adopting sets of indicators that were already developed in previous researches served two purposes. On the one hand, the researcher of this thesis could be certain that questions were understandable and participants were also willing to answer them. On the other hand, this decision saved time because the reliability of the indicators was already tested and verified (Bryman & Bell, 2011). The final selection of the multiple indicators and their sources are displayed in the previously shown Table 1.

It was decided to use closed-ended questions because this decreases the chances of abortion as people tend to favour choosing a given option over answering in writing. For the researcher, this choice came with the additional benefit of a supposedly easier data processing. Moreover, such questions are easier for participants to understand which in turn supports to reduce the risk of misunderstandings. All questions in the questionnaire were closed-ended questions. With the aim to further reduce the possibility of misunderstandings, the researcher of this thesis decided to include instructions about the answering process of the questionnaire as well as an introduction text to the concept of IoT (see Appendices 3 and 4). The goal of the introduction text was twofold. One the one hand, the text helped participants to refresh the memories about the topic of IoT. On the other hand, it gave participants who never heard about IoT technology a definition and demonstrated what possibilities IoT technology creates. Furthermore, it was avoided to use technical terms, abbreviations or double-barreled questions in order to reduce the risk of confusion. Throughout the questionnaire, only one abbreviation, namely IoT, was used but also explained in the introduction text. Moreover, the researcher did not use leading questions because they

tend to influence the participants to answer in a certain way (Bryman & Bell, 2011; Saunders et al., 2009).

Once it was assured that the questions were understandable and relatively easy to answer, it needed to be determined how participants answer the questions. The choice was made for a 5-point Likert scale. This was mainly done because the set of questions were taken from previous research (Gao & Bai, 2014; I. Lee et al., 2007; Mital et al., 2016) that also applied a 5-point Likert scale. Participants were asked to respond to several statements with a range from strongly disagree to strongly agree. The choice in favour of a 5-point Likert scale instead of a 7-point Likert scale was also made because it was acknowledged to be less confusing for participants which can have a positive effect on the response rate. Additionally, the 5-point Likert scale is more appropriate for a European context (ResearchGate, 2015). Following the suggestion of Saunders et al. (2009), the researcher of this thesis avoided to include reverse scales. Not switching up the order of the categories in a sequence of statements ensures clearness.

(3) Structuring the questions

All questions of the questionnaire were structured in an order that is logical for the participants. Participants were first shown an introduction text that explained the purpose of the questionnaire and a text with a definition as well as examples of application of IoT technology. This was followed by two closed-ended questions about the self-evaluation of how well participants knew about the topic of IoT technology and which IoT technology they are already using. After that, participants reached the main part of the survey where they answered to what degree they agreed or disagreed with the different scale items. If a participant already used IoT technology, they were not shown any questions related to intention to adopt because they already acted on their intention. Ultimately, the questionnaire asked participants to give demographical background information and gave instructions about how to finish the survey.

(4) Translation of the survey

At the beginning, the questionnaire was designed in English because the original scale items were taken from the literature in this language. Nevertheless, the aim of this thesis is to research the German market and the targeted survey participants speak German. Most people respond positively if they can answer a survey in their native language which is why the entire questionnaire was translated into German. Since the researcher of this thesis is a native German, he was able to translate the questions and respective answers as close as possible to the original. Consequently, it was also possible to avoid lexical, idiomatic, or experiential mistakes.

(5) Designing a fitting layout

According to Saunders et al. (2009), a questionnaire can be supported to generate more valid data when it is designed with a professional appearance. The layout of the questionnaire was designed with the online survey tool 'SurveyXact'. 'SurveyXact' offers a variety of templates to design the questionnaire. Furthermore, the questionnaire is automatically formatted to be compatible with computers or mobile devices. With the aim to decrease distraction or confusion, the researcher of this thesis chose to design the questionnaire in a simple and consistent layout. Another option, that 'SurveyXact' presents, is to program, filter, and organise the questions in the survey. Showing only a limited amount of questions per page makes the questionnaire appear shorter. Resulting from that, participants feel less likely to leave the survey prematurely. Altogether, 'SurveyXact' did not only prove useful in the process of designing the questionnaire but also in the collection of the data (Bryman & Bell, 2011; Saunders et al., 2009).

(6) Pre-testing the questionnaire

By pre-testing the questionnaire, it was made sure that the collected data is both reliable as well as valid (Saunders et al., 2009). The questionnaire was tested, back-checked and evaluated with four independent potential participants from Germany (Bryman & Bell, 2011; Saunders et al., 2009). Within the first round of testing, two potential participants of the study were asked to answer the questionnaire and give

feedback in terms of difficulty, length of the survey, or any issues they noticed in the process of answering. Based on this feedback, the researcher of this thesis made little changes regarding the structure and wording. This adapted survey was then tested with another two potential participants and they were asked to give feedback again. Since these testers did not mention any further issues, the pre-testing was completed.

(7) Send out survey

The final stage of the survey development was to plan and execute the administration of the questionnaire. For both of these aspects, 'SurveyXact' was used as already previously mentioned. Potential participants were either reached through the website SurveyCircle or the social media platform Facebook. The website SurveyCircle is based on mutual support. Researchers can share their surveys on this platform to access a different sample than their personal friends for example and also support other researchers by participating in their research. On Facebook, the link to the survey was posted in several German university related groups (e.g. HSD Wirtschaftswissenschaften or International Management HSD) as well as the personal Facebook page of the researcher. From there, it was shared another two times by others on their respective personal Facebook pages. After three days, a follow-up message was posted in each Facebook group and the personal channels three days after the initial post to remind the members to participate in the research.
SurveyCircle and Facebook were mainly used because of resources the researcher of this thesis had to experience and these two ways of distribution presented a good possibility to reach many potential participants. Data was collected for a period of one week in April 2019.

2.8 Sampling

Research in the field of IoT technology adoption in Germany is scarce which is why the researcher of this thesis chose to focus on the German market. Additional reasons for choosing this research in the German market are that technology is a personal field of interest of the researcher and the German market presents attractive opportunities for employment in the future. Participants of the survey needed to live in Germany but were not limited to German nationality only. Based on the focus of this thesis to

research determinants of the intention to adopt IoT technology in Germany, everyone living in Germany was suitable to answer the research. Nevertheless, it must be mentioned that the thesis at hand did not have the opportunity to access a probability sample because of the given resource restrictions. Instead, the research chose to apply a non-probability sample method with a convenience sampling (Bryman & Bell, 2011; Saunders et al., 2009). The restrictions in time and money were an additional reason against a probability sampling method, and in favour of a non-probability sampling method, because these two resources are needed to handle the huge amount of data that is generated with this method (Daniel, 2012).

2.9 Data Processing

Before data can be analysed, it first needs to be processed. According to Saunders et al. (2009), raw data has only little meaning. Only when it is processed, it can be turned into valuable information. Mistakes in the processing of data, for instance caused by incorrect data management, can be the reason for errors in the data processing and have an impact on both research reliability and validity (Bryman & Bell, 2011). 'SurveyXact' already processed the data to some extend and enabled the researcher to pull data sets that were already pre-coded and exportable as a Microsoft Excel file. Thus, it was not necessary to manually code the answers of the participants and transfer them to the software used for analysis. Resulting from that, both necessary time and probability of processing errors were reduced. However, the data needed to undergo additional processing steps.

To begin with, the level of completion was used to further process the data. Incorrect or incomplete surveys resulting from abortion were left out which reduced the recorded data sets to 193. Then, participants of the research had to be living in Germany which further reduced the data sets to 189. Since this thesis aims to research the intention to adopt, respondents who already adopted IoT technology were excluded and the data set was reduced to 158. Lastly, data sets with fictional inputs such as an unrealistic age of widely over 100 were supposed to be deleted. However, this did not apply to any of the recorded data. Thus, the final data set consisted of 158 responses for the analysis. Ultimately, this set of data was imported into the statistical analysis software SPSS version 25 for further data processing and analysis.

The first step undertaken within SPSS was to label the variables of the data sets and translate them back to English. Due to the reason that this thesis employs a regression analysis, the scales were adapted to interval scaled items (Institute for Digital Research and Education, 2017). There is an argument between researchers whether the 5-point Likert scales should be ordinal or interval (ResearchGate, 2014). The argument in favour of a decision to consider the Likert scale as ordinal is that one cannot be certain that each distance between the measurement values is identical. Nonetheless, the research of this thesis stands with the opposition that considers the distances to be identical which is why the Likert scales were coded as interval items (Institute for Digital Research and Education, 2017).

Ultimately, composite variables were created for the constructs of PU (five variable measures), PEOU (five variable measures), trust (four variable measures), social influence (three variable measures), and intention to adopt (three variable measures). Since the individual variable measures were taken from previous research (see Chapter 2.6), they were not further tested for reliability but tested with Cronbach's α.

After having done that, the processed data set was prepared for the ensuing data analysis.

2.10 Data Analysis Method

The data analysis was also carried out with the statistical tool SPSS. Cronbach's α was calculated to test the reliability of the composite variables. Furthermore, the relationship between the independent and dependent variables was researched with a multiple regression analysis. Multiple linear regression analysis is a valid approach to investigate whether independent variables have the power to predict or explain dependent ones (Hair, Black, Babin, & Anderson, 2010). Prior to the multiple regression analysis, the different variables were additionally tested via bivariate Pearson Correlation. By doing so, the researcher of this thesis was able to identify if there are relationships between the individual variables, and if yes, how strong or statistically significant they are. Pearson's r helps to evaluate whether the multiple regression analysis can be performed on the variables under investigation and indicates whether the null hypothesis is rejected or supported. Nevertheless, it should

be mentioned that Person's *r* can identify a relationship between two variables, but not its direction.

2.11 Quality Criteria

Based on Bryman and Bell (2011), Saunders et al. (2009), as well as Yin (2014), quantitative research should include reflections on the validity and reliability. Such reflections help to critically evaluate the underlying research.

According to Bryman and Bell (2011, p. 159), validity "refers to the issue of whether or not an indicator (or set of indicators) that is devised to gauge a concept really measures that concept". It was already previously stated that the constructs measured within the study were taken from previous research where they were successfully tested and verified. Accordingly, the construct validity can be considered given.

The second quality criteria, reliability, "refers to the consistency of a measure of a concept" (Bryman & Bell, 2011, p. 158). In other words, reliability refers to the replicability of the results when the study is repeated by another researcher (Yin, 2014). There is a multiplicity of measurements to investigate the reliability (e.g. stability, inter-observer consistency). One of the most relevant ones is internal validity which this thesis also focusses on. Internal validity refers to how consistent an indicator performs in a multiple-indicator setup. The previously mentioned Cronbach's α is commonly used in literature to test this internal reliability. Within this thesis, all indicators were above the cut off level of 0.70 (Bryman & Bell, 2011). Furthermore, the reliability is supported by the applied cross-sectional research design and its requirements of a detailed documentation of the taken steps during the research (Bryman & Bell, 2011; Yin, 2014). The highly structured methodological chapter in this thesis ensured reliability and replicability (Saunders et al., 2009). The documentation over the course of this thesis was done as meticulous and detailed as possible.

Based on this argumentation, steps were taken to ensure reliability and validity within this research. Thus, the quality of the research can be graded as rather high.

3. Literature Review

The literature review chapter will present several theories that form the foundation of the framework developed within this thesis. The chapter will start by introducing what IoT technology is. Afterwards, there will be a closer look on how consumers adopt new technologies. This is followed by illuminate the different adoption theories in more detail. Ultimately, the chapter ends by presenting the different hypotheses as well as presenting the developed framework.

3.1 Internet of Things

3.1.1 Definition & Characteristics of the IoT

As the IoT is one of the crucial constructs in this thesis, it is important to describe how this research defines it. There are three common definitions of the term within the literature (Lu et al., 2018). Atzori, Iera, & Morabito (2010, p. 2788) describe the IoT as “a world-wide network of interconnected objects”. These interconnected objects have a pervasive presence in consumers’ lives and can be uniquely addressed. They have the ability to interact with other connected objects or react to their physical environment. Another definition was created by the International Telecommunication Union (ITU). They state that any physical or virtual IoT object “is capable of being identified and integrated into communication networks” (ITU-T Y.2060, 2012, p. 1). Another frequently adopted definition, is the one by the European Commission (2014). IoT is defined as “objects sharing information with other objects/members in the network, recognizing events and changes so to react autonomously in an appropriate manner. The IoT therefore builds on communication between things (machines, buildings, cars, animals, etc.) that leads to action and value creation” (European Commission, 2014, p. 18). This definition is also adopted within this research.

The three different definitions agree on some common characteristics. IoT technology has a pervasive presence and it acts within a dynamic network in which it can be identified and addressed uniquely. Communication with IoT products occurs “either among themselves building networks of interconnected objects, or with end-users or

other entities in the network" (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012, p. 1498). These forms of communication enable IoT products to efficiently share real-time information and execute actions based on these information (Lu et al., 2018). A real life consumer example of IoT technology implementing all of this would be a smart thermostat to regulate the temperature in a household such as the one from Google Nest (Nest, 2018b) as already mentioned earlier. Temperatures can either be changed manually via a smartphone app (i.e. through end-users) or automatically by the thermostat for instance through communication with local weather stations (i.e. interconnected (physical) objects or other entities). In case a household owns several interconnected IoT devices, the devices can additionally communicate with each other within this ecosystem. For instance, a smart speaker like the Amazon Echo possesses the capability to process spoken words and to communicate in real time with a smart thermostat such as the Google Nest (Nest, 2018a). Consequently, owning these two devices enables consumers to adjust the temperature by voice commands which creates benefits through convenience for consumers. As IoT technology can both gather information from and interact with the physical world, the borders between the physical and digital world blur.

3.1.2 Current and Future Developments

Businesses have implemented IoT technology in the form of RFID already decades before IoT technology was a field of interest for private end consumers (Yonck, 2013). Already in 2008, "the number of devices connected to the Internet exceeded the number of people on Earth" (Evans, 2011). Literature agrees that the IoT technology will have a massive impact on the future of private users and is here to stay (Liew et al., 2017; Lu et al., 2018). When classified according to the adopter categorisation by Rogers (1983) of Innovators, Early Adopters, Early Majority, Late Majority, and Laggards, the IoT market is currently transitioning from an early adopter market to an early majority one (Shin, Park, & Lee, 2018). According to the classification of Rogers (1983), this means that it can be estimated that IoT technology is currently only penetrating about a sixth of the market (Bae & Chang, 2012). By the end of 2018, analysts believe that 23.14bn IoT devices will be active and communicating with the Internet and each other worldwide (Statista, 2018a). To a great extent, this is due to the increased consumption of private consumers. Expectations additionally state that

IoT technology will have found its way into 7.5 per cent of global households generating revenues of US$48,710m. Merely within the next four years, it is expected that the number of active devices will almost double to 42.62bn (Statista, 2018a). Approximately every tenth household (19.5 per cent) will own IoT devices and the private IoT market will generate revenues of US$121,960m (Statista, 2018b). To a great extent, this growth results from the rapid technological progress that technology has experienced during the past decade as seen with smartphones, wearables, or the speed of Internet which also reflects in how IoT technology is connected and used in private homes (Qasim & Abu-Shanab, 2016). IoT technology transitioned from stand-alone solutions to integrated solutions capable of communicating with other smart devices in the household (Statista, 2018c). Such smart technology finds application in an increasing number of segments within the household like control and connectivity (e.g. hubs controlling other devices, or digital assistants), comfort and lightning (e.g. smart bulbs, or window sensors), security (e.g. door locks, or smoke sensors), home entertainment (e.g. multiroom entertainment systems, or entertainment remotes), energy management (e.g. thermostats, or air condition controls), or smart appliances (e.g. fridges, or coffee machines) (Statista, 2018c). More and more objects that used to be ‘dumb’ (i.e. without smart technology) will become IoT enabled. A possible everyday scenario involving IoT devices could be the following: a meeting is pushed back for an hour. Resulting from that, the Internet-connected alarm clock automatically adjusts, grants some extra minutes of sleep, and parallelly communicates with the alike Internet-connected coffee machine to brew fresh coffee equally delayed. All of this happens without any human interference. The more personalised and helpful such devices will get, the higher will also be the expectation of consumers towards technology. This is in accordance with what Evans (2011) states. As technological limitations are pushed constantly to new extremes, innovation is only limited by human imagination.

One, if not the most important aspect of this technology is that the most value can be created by forming an ecosystem of IoT technology through connecting it to the Internet and enabling the technology to seamlessly talk to each other (A. Miller, 2017). Thus, whenever a new device is added into this ecosystem, it is not only consumers who gain access to the function of that new device but so do also the existing devices which increases the value of the technology. For instance, it is already of value for a

consumer to get a message that a sensor on the washing machine detected a water leak and he or she can close the water take quickly. Though, it would be of even more value if the sensor immediately communicates with the water intake to close. This interconnection of technology changes how consumers live their live but also how companies can reach them (M. Miller, 2015).

Beyond that, there are plenty of other use case scenarios in which IoT technology facilitates consumer lives. For instance, health data can be tracked on a regular basis because it is needed (i.e. glucose levels or blood pressure) or preventative (i.e. monitor heart irregularities) and also directly transmitted to a doctor (Shah, 2014; Ukil, Bandyoapdhyay, Puri, & Pal, 2016). IoT technology can also enable patients with special needs and limited mobility to remain more independent and live in their own home because they can control things in their home digitally (Rialle, Duchene, Noury, Bajolle, & Demongeot, 2002). Additionally, IoT technology enables everyday consumers to shop in stores without cashiers or check outs (Garun, 2016).

As useful IoT technology may be, potential consumers still encounter adoption barriers (Mani & Chouk, 2017; Yang et al., 2017). The full potential of consumer IoT technology can only be achieved when companies identify and counter these barriers as well as support potential consumers in their decision making to adopt the technology.

3.1.3 Adoption Opportunities and Barriers

Having to overcome adoption barriers before being considered by consumers is not an issue that is exclusive to IoT technology but was a challenge for numerous other innovations in the past as well because they were different than products available at that time. The identification of adoption barriers is an important step in the commercialisation of an innovation as potential consumers are confronted with them already during the early stages of their decision-making. Adoption barriers can be categorised as functional barriers (i.e. how potential consumers perceive value and risk of usage) and psychological barriers (i.e. how potential consumers believe an adoption will impact him or her). The latter ones are also sometimes named social barriers (Balta-Ozkan, Boteler, & Amerighi, 2014). Looking a little bit deeper and at the IoT technology in particular, Balta-Ozkan et al. (2014) empathise that control and

security are crucial barriers to overcome. Beyond that, consumers are faced with technical, conceptual, as well as management barriers when adopting IoT technology.

When looking at the technical barriers, technology should be flexible and able to adapt to the constantly changing lifestyle many consumers live nowadays. If the technology fails to do so, there is the possibility that consumers feel that it is outdated quickly (Balta-Ozkan et al., 2014). From the conceptual side, IoT technology should be easily integrated into consumer homes and already existing ecosystems. Additionally, IoT technology should allow to be updated and extended with future devices (W. Li et al., 2012; Stringer, Fitzpatrick, & Harris, 2006). However, there is a high probability that devices from several different manufacturers have to work together within such an ecosystem. The interoperability is not assured as there is no clear standard in the IoT sector and new devices may not work with the existing ones (Balta-Ozkan et al., 2014). Lastly, when consumers perceive that they are out of control and the technology is complicated to manage or the technology requires them to adjust for instance their routines to it, it is less likely to be adopted (Chikhaoui & Pigot, 2010; W. Li et al., 2012).

Additionally, technology needs to be maintained which can be seen as another barrier. While it is true that a certain amount of this maintenance can be done by third-parties, consumers also want to individualise their system which means that the configuration is somewhat subjective and users need to have some level of knowledge (i.e. troubleshooting or system management) on their own (Balta-Ozkan et al., 2014). Here, it should also be noted that this can come with the risk of malfunctions because of mismanagement. How high the tolerance level for malfunctions is varies according to the importance of the technology in the system. For instance, a fire alarm would have a lower level of malfunction tolerance in comparison to a smart speaker because it can make the difference between life and death (Friedewald, Da Costa, Punie, Alahuhta, & Heinonen, 2005).

Maintainability as well as upgradeability of technology usually only becomes an adoption barrier several years after the introduction of an innovation. However, potential consumers are starting to encounter this barrier with consumer IoT technology (BCS The Chartered Institute for IT, 2017).

The great amount of data generated, processed, and invisibly communicated between the devices is a very sensitive topic in the context of IoT technology and creates privacy and security barriers. It is a necessity for IoT technology to collect and process data in order to achieve the best results and thus benefits. Companies offering IoT technologies have to assure that user data is strictly protected and that systems such as smart locks or smart heating are not in danger of being breached (Balta-Ozkan et al., 2014).

Research of the past oftentimes argued that innovation characteristics have to be the centre of attention but nowadays, research focusses on ways to increase the intention of consumer to adopt (Rogers, 2003). Due to the rapid advances in technology, consumers are also faced with an increased amount of product launches (Goffin, 1998). While some of these launches are just updates to existing and familiar technology, market changing innovations such as smartphones oftentimes come with unknown components or unfamiliar interfaces (Ziamou, 2002). Despite being from the same brand or the same kind of product, this can be a reason for an impeded compatibility with existing technology because, for instance, a different software is needed (Katz & Shapiro, 1985). This uncertainty of future compatibility and the absence of a common direction of IoT technology was identified as a high barrier to adoption (BCS The Chartered Institute for IT, 2017). There have been attempts to create a standard but the government, producers, and academics all have a different vision of how the IoT architecture should look like and several versions exist (BCS The Chartered Institute for IT, 2017).

Addressing and solving such issues could be pivotal to an increased purchase intention and adoption behaviour of potential consumers (Miorandi et al., 2012).

3.2 Technology Adoption

Several theories and models were developed to research additional technology adoption factors (Gao & Bai, 2014; I. Lee et al., 2007; Mital et al., 2016). Within this chapter, a selection of the most suitable models to research IoT technology adoption will be discussed. An overview of research in the field of IoT technology adoption will be given which is followed by outlining the most frequently used theories and models.

Lastly, the chosen research model, namely the Technology Acceptance Model (TAM), will be discussed more thoroughly regarding the suitability for the research at hand.

Before moving forward, it should further be pointed out that the relationship of the concepts of technology *adoption* and technology *acceptance* needs to be discussed. Previous research distinctly distinguished the two concepts of technology adoption and technology acceptance. Lu, Papagiannidis and Alamanos (2018) argue that potential customers first need to have a positive attitude towards technology (acceptance) before actually purchasing it (adoption). However, this explanation also demonstrates that it is possible to use the two concepts interchangeably because adopting a technology also means accepting it. Additionally, distinguishing these two concepts too strictly may result in a confused reader. Thus, the research at hand uses the terms technology acceptance and technology adoption interchangeably.

3.2.1 Research on the Field of IoT Technology Adoption

A great amount of previous research on the topic of IoT technology was done from an organisational perspective. Within a systematic literature review about IoT from user and organisational perspectives, Lu et al. (2018) identified that IoT products and services find application on four levels, namely the infrastructural (i.e. smart cities, or smart tourism), organisational (i.e. smart logistics, or smart agriculture), individual (i.e. smart home, or smart security), and all-inclusive one (i.e. smart transportation, or education). Though, as the aim of this thesis is to research the determinants of the intention to adopt IoT devices from a consumer perspective, research on the individual level of IoT application is the most relevant one.

3.2.2 Technology Adoption Theories

It is difficult and complex to predict human behaviour. This is why explaining the adoption of recently introduced or developing technology is also very challenging to research. Over the course of more than two decades, researchers have created several theories and models in this field (Alomary & Woollard, 2015).

There is a consent in previous literature (Bae & Chang, 2012; Gao & Bai, 2014; Lu et al., 2018; Samaradiwakara & Gunawardena, 2014; Shin et al., 2018; Taherdoost, 2018) that the most dominant theories and models in consumer technology adoption are the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975), the Theory of Planned Behaviour (TPB) (Ajzen, 1991), as well as the Technology Acceptance Model (TAM) (Davis, 1985) because they were frequently applied in a variety of technology adoption scenarios and proved to be reliable. The three mentioned theories share a great amount of similarities.

3.2.2.1 Theory of Reasoned Action

Although the TRA was initially developed for sociological and psychological researches (Taherdoost, 2018), it is oftentimes referred to as the first model with widespread recognition to research the acceptance of technology (Samaradiwakara & Gunawardena, 2014). The TRA proposes that “behavioral intentions, which are the immediate antecedents to behavior, are a function of salient information or beliefs about the likelihood that performing a particular behavior will lead to a specific outcome” (Madden et al., 1992, p. 3). Within the model (see Figure 2), the two variables of attitude and subjective norm (SN) form the behavioural intention (BI) to actually perform a behaviour while having an antecedent each (i.e. behavioural beliefs and normative beliefs). Normative beliefs include the individual’s beliefs about how important others want the individual to perform a certain behaviour (Davis, 1985; Fishbein & Ajzen, 1975).

Despite being parsimonious and easy to use, the TRA was also criticised for not addressing the role of human habits, moral factors, and that there is also “behavior over which people have incomplete volitional control” (Ajzen, 1991, p. 181; Taherdoost, 2018).

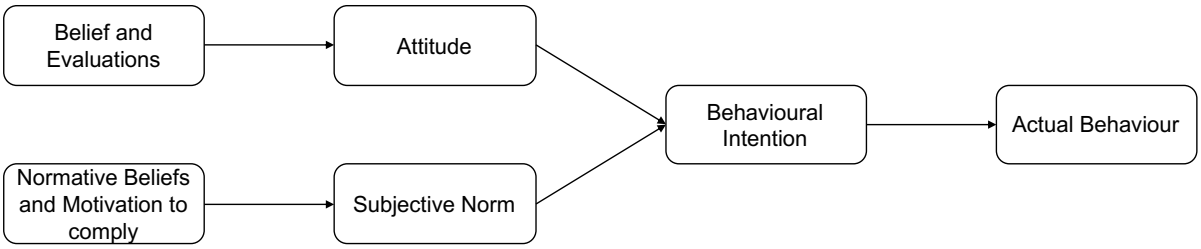

Figure 2: Original Theory of Reasoned Action Model (Fishbein & Ajzen, 1975)

3.2.2.2 Theory of Planned Behaviour

Ajzen (1991) aimed to counteract the previously mentioned weaknesses of the TRA within his model of the Theory of Planned Behaviour by including the variable of perceived behavioural control (PBC) as an antecedent of a behaviour. This variable refers to how well an individual perceives to be able to execute a behaviour. PBC is influenced by the availability of resources, or opportunities and skills while influencing behaviour both directly as well as indirectly through BI. In other words, PBC can also be described as an individual's confidence in his or her own abilities. Other research also names this self-efficacy (Davis, 1989). Compared to the TRA, the TPB also assumes that behaviour is determined by BI. However, through further research, Ajzen (1991) found that the initial way of measuring BI, as the trying to perform a behaviour, is tedious to measure. Instead, he decided to measure it through actual performance of a behaviour. Additionally, including the factor PBC addresses a limitation of the TRA in that it also acknowledges human actions that may also be non-volitional (i.e. out of the control of an individual) (Ajzen, 1985, 1991). Just as with the TRA, this model is not without criticism as well. According to the TPB, an individual's attitude is irrelevant if the technology is not accessible. Thus, the TPB only considers external factors while neglecting perceived individual factors (Taherdoost, 2018).

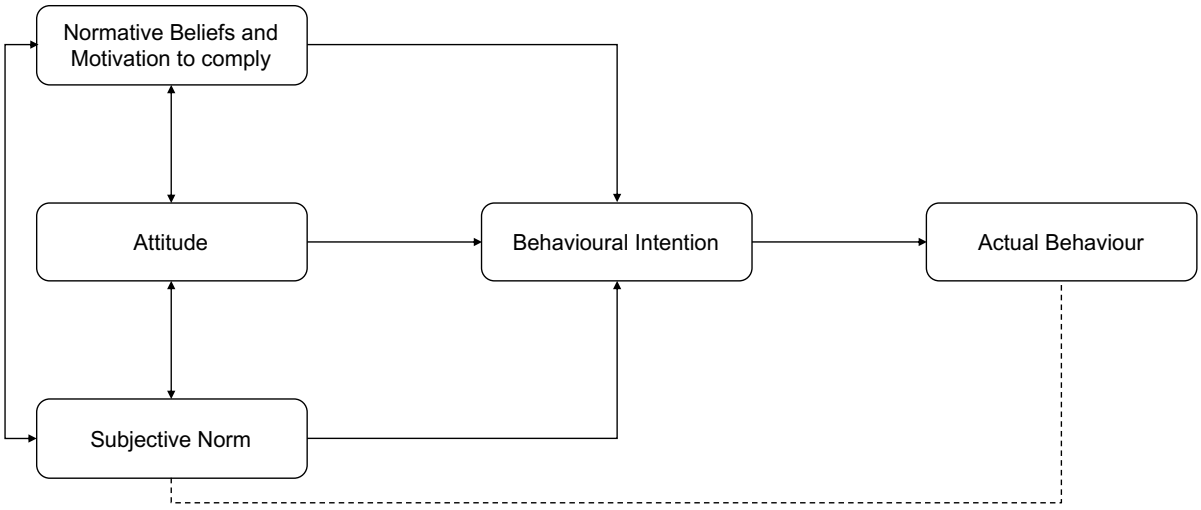

Figure 3: Original Theory of Planned Behaviour Model (Ajzen, 1991)

3.2.2.3 Technology Acceptance Model

The TAM was introduced by Fred Davis in his 1985 doctoral thesis which sought to "improve our understanding of user acceptance processes" (Davis, 1985, p. 2) and explain both reasons for adopting technology and the process behind it. This conceptual model is based on the TRA and was designed to research the adoption of computers in a work-related context in particular. In contrast to today, most households did not have access to a computer and research on this topic was scarce. However, computers are an essential part of many households nowadays and the TAM was applied in several other fields. The TAM is considered to be one of the most powerful models to explain adopting behaviour of IT technologies because it comprises a very suitable set of measurement scales and is referred to as one of the most influential theories from the consumer perspective (Wu & Ke, 2015). Previous research already acknowledged the fit of the TAM to research the adoption of IoT technology (Liew et al., 2017; Lu et al., 2018; Shin et al., 2018).

It is assumed that the versatility of the TAM results from its simplicity (Ur Rehman, Rizwan, Ud din Ahmed, Ali, & Khan, 2013). The model postulates that technology adoption is determined by the three variables of perceived usefulness (PU), perceived ease of use (PEOU), and attitude toward technology. PU is defined as "the degree to which an individual believes that using a particular system would enhance his or her job performance" (Davis, 1985, p. 26), PEOU as "the degree to which an individual

believes that using a particular system would be free of physical and mental effort" (Davis, 1985, p. 26), and attitude as "an individual's positive or negative feelings (evaluative effect) about performing the target behavior" (Fishbein & Ajzen, 1975, p. 216). During the last decades, the TAM was revised several times. In Davis' version of 1989, BI was added as a variable to the model. It was postulated that BI is equally indirectly influenced by PU and PEOU and directly through attitude towards technology. Figure 4 illustrates Davis' (1989) revised model.

Initially, the TAM included the variable 'design features' which was replaced by 'external variables' (i.e. surrounding influences such as system characteristics, or user training), to include the individual perception of how useful a technology is in helping to complete a task. Moreover, those external variables also directly influence the individual perception of how easy the technology is to use. Additionally, PEOU also affects PU. Davis (1989) posits that the more an individual perceives that it is easy to use a technology, the more may an individual also utilise a technology. With increased usage, the technology will also become more useful which increases the PU. Both PU and PEOU furthermore influence the attitude toward using technology of an individual and ultimately the actual system use (Davis, 1985).

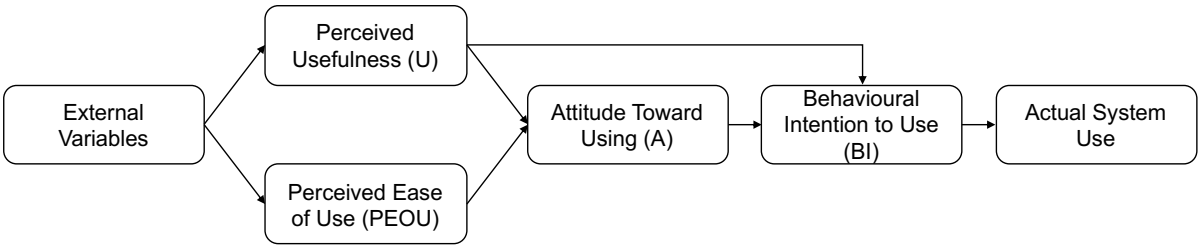

Figure 4: Original Technology Acceptance Model (Davis, 1989)

While BI was initially influenced by PU and attitude toward technology, the latter factor was later removed because its effect on BI decreases with time and it was found that PU and PEOU exert a powerful impact on BI on their own (Venkatesh & Davis, 1996). However, it should be additionally noted that excluding the attitude variable also means that BI functions as a mediator between PU as well as PEOU and actual behaviour. There is a controversy in previous research whether intention is also leading to behaviour but there is also evidence that intention is a valid substitute for actual behaviour (Fishbein & Ajzen, 2005). Nevertheless, this thesis does not measure

whether a participant acted upon a previous intention to adopt IoT technology. Researching the path of forming an intention and then acting upon it would require a longitudinal research with pre- and post-adoption data of the same participants which exceeds the resources and extent of this research.

As with almost every model, the TAM is not free of criticism. Some researchers call for an inclusion of the variable of SN but there are several reasons why Davis (1989) did not include this variable in the TAM. As previously mentioned, computers were not common at the time of the creation of the TAM. Since most people have not been in contact with computers, hardly any normative beliefs could have been drawn from important others. Moreover, Fishbein and Ajzen (1975) admitted themselves that SN was oftentimes misunderstood. However, there were approaches to implement SN within the TAM2 (Venkatesh & Davis, 2000) as well as a version of the TAM by Holden and Karsh (2010). Nevertheless, modifications of the TAM including the variable SN have not found the same extent of application and advocacy as the original TAM.

Furthermore, the role of PEOU in the model is criticised. Davis (1989) acknowledges that PU has a significantly stronger relationship to actual behaviour in comparison to PEOU by stating that “users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those functions” (Davis, 1989, p. 333). There is research (Gao & Bai, 2014) that agrees with Davis’ (1989) view that PEOU influences both BI and PU because technology can only be used to its fullest potential when users also know how to use it. The easier a technology is to use, the more of its potential can be reached.

Another point of criticism is the context of the TAM. The model was intended to be used to research the acceptance of IT technology in a work-related environment while this thesis aims to research IoT technology adoption in a consumer household. When consumers adopt IoT technology, they do it on a voluntarily basis and chose freely from alternatives. This is not the case for a work-related context because this is typically mandatory and without alternatives (Fayad & Paper, 2015). While consumers always have the alternative to use regular ‘dumb’ devices (i.e. simple and not connected ones), there is no real alternative to achieving the goal of IoT technology to

increase convenience through automation and giving remote control (i.e. saving time and money).

Despite these criticisms, there are some researches that compare the TAM to the TRA and TPB for instance in an IoT adoption context (Mital et al., 2016) or an Internet banking context (Yousafzai, Foxall, & Pallister, 2010). Both researches come to the conclusion that the TAM is superior in comparison to the TRA and TPB in terms of model fit and explaining actual behaviour. While the simplicity of the TAM is oftentimes emphasised as one of the strengths of the model, Bagozzi (Bagozzi, 2007, p. 244) also stresses that it can be a weakness by stating that “it is unreasonable to expect that one model, and one so simple, would explain decisions and behavior fully across a wide range of technologies, adoption situations, and differences in decision making and decision makers”. Nonetheless, the model’s simplicity leaves room for adaption to differing contexts. Researchers must see this as a valuable option to individualise the model with additional variables in order to suit their specific research context (Chong, Chan, & Ooi, 2012). The option to do so makes the TAM both flexible and powerful (Alomary & Woollard, 2015). Based on the previous argumentation and considering the alternatives, the researcher of this thesis decided that the TAM is suitable to research IoT technology adoption.

3.2.3 Research Model

After reviewing relevant literature in the field of technology adoption, the researcher of this thesis has decided to include four variables. All four variables were found to be significant indicators for technology adoption in various contexts. Thus, the TAM, and its initial variables of PU and PEOU, was extended by the variables of trust and social influence. The entire model is displayed in Figure 5 below.

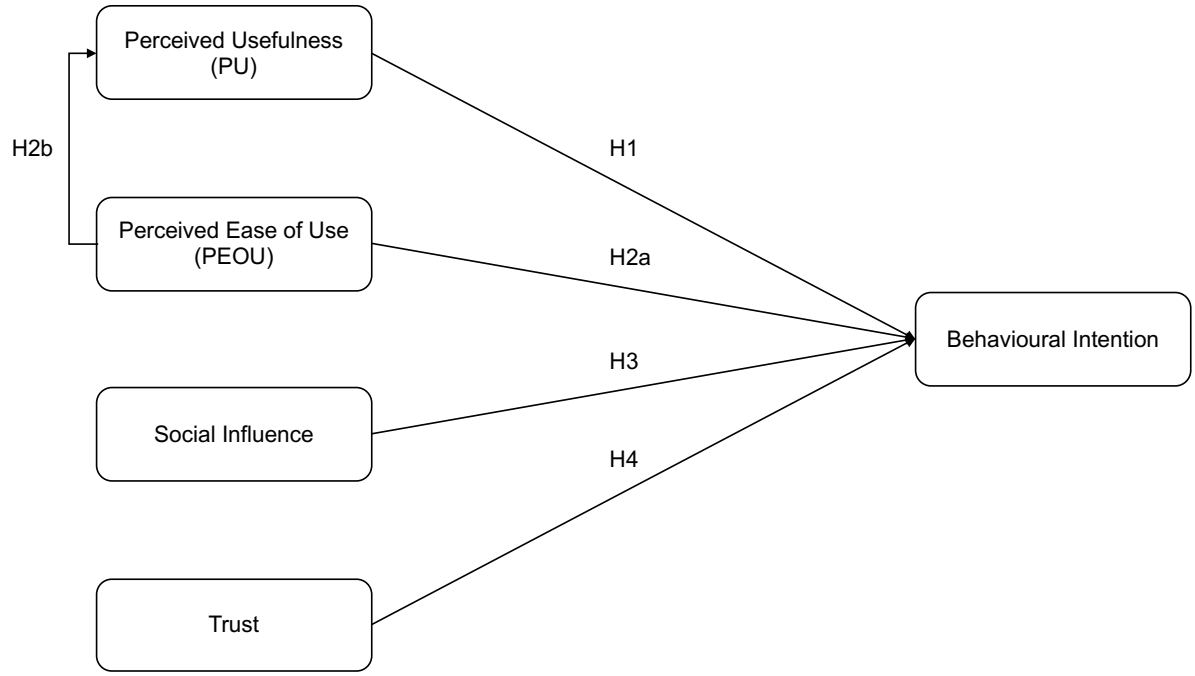

Figure 5: Proposed Research Model

3.2.3.1 Perceived Usefulness

This thesis defines PU as “the degree to which one believes that using the technology will enhance his/her performance” (Gao & Bai, 2014, p. 214). In other words, PU refers to the degree to which IoT technology is believed to improve a consumer’s everyday life through convenience for instance (Cho & Sagynov, 2015). The importance of PU in consumer decision making was already acknowledged by Rogers (1995) when he found out that technological changes are most likely to be accepted when they also provide a distinctive advantage in comparison to the currently used technology. IoT technology is such a transformation technology because it supports consumers in their daily life by reducing energy consumption for instance and increases consumer satisfaction (Liew et al., 2017). With increased satisfaction, consumers will also perceive an enhancement of performance and they are more likely to adopt the technology. Previous research has already found IoT technology to be very useful in a business setting. For instance, retail stores can utilise IoT technology to process goods faster which in turn reduces waiting time and increases customer satisfaction (Gao & Bai, 2014). Additionally, Wang, Zhang, Quan and Dong (2013) found IoT technology to be very useful in the railway section where the efficiency of maintenance can be improved.

In the context of consumer IoT technology, Liew et al. (2017) argue that potential consumers perceive such technology as more useful because of an increase in processing speed and convenience. Everyday scenarios with IoT technology include increased security through connected cameras or RFID door locks, reduced utility costs through automated heating systems or windows, and increased quality of sleep through wearables or connected alarm clocks. Beyond the IoT technology cases (Gao & Bai, 2014; Liew et al., 2017; Mital et al., 2016; Shin et al., 2018), other research already established the connection between PU and the intention to adopt technology in various other IT contexts (Chi, Yeh, & Yang, 2011; Chong et al., 2012; Y.-K. Lee, Park, Chung, & Blakeney, 2012). However, the slow diffusion of consumer IoT technology demonstrates that potential consumers do not perceive that IoT technology provides significant benefits over existing options.

Correspondingly, this thesis adapts PU as an important predictor for the intention to adopt consumer IoT technology. The findings from extant research are taken up and it is proposed that:

> ***H1.*** *Perceived usefulness has a significant and positive relationship with consumer decisions to adopt IoT technology.*

3.2.3.2 Perceived Ease of Use

Furthermore, PEOU is another individually perceived variable that plays an important role in consumer decision making. This thesis defined PEOU as “the degree to which an individual believes that using a particular system would be free of physical and mental effort.” (Davis, 1985, p. 26). Correspondingly, technology is supposed to be installable, usable, as well as manageable by everyday consumers without too much effort (Cho & Sagynov, 2015). It was already stated that behavioural intentions are influenced to a great extent by convenience and complexity (Y.-K. Lee et al., 2012; Liew et al., 2017). IoT technology can be considered as such a potentially inconvenient and complex technology because different products and services come together in an ecosystem (Dodgson, Gann, & Salter, 2008). Extent literature studied the concept of PEOU in numerous IT contexts (Chi et al., 2011; Chong et al., 2012; Gao & Bai, 2014;

Liew et al., 2017; Mital et al., 2016; Shin et al., 2018) and identified it as a significant determinant of technology adoption (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Y.-K. Lee et al., 2012). Since IoT technology can be considered a complex technology, users can get the most benefits from the technology when they are also able to use it to its fullest potential. This is influence of PEOU on PU is also what the TAM postulates (Davis, 1989; Gao & Bai, 2014).

Accordingly, this thesis proposes the following hypothesis for testing:

> ***H2a.*** *Perceived ease of use has a significant and positive relationship with consumer decisions to adopt IoT technology.*

> ***H2b.*** *Perceived ease of use has a significant and positive relationship with perceived usefulness of IoT technology.*

3.2.3.3 Trust

Beyond PU and PEOU, the literature review revealed that trust is also a central element in the adoption process of new technology (Gao & Bai, 2014). As consumer IoT technology is still relatively new, most potential consumers do not have many experiences with the use of technology such as Internet enabled security cameras or smart home speakers. Among other functions, IoT technology is also capable of making purchases for its users. However, many potential consumers are particularly afraid about the security of their financial information (Weber, 2015). The fact that the flow of data within IoT technology is not comprehensible for consumers, because all information exchange happens automatically and invisible, only increases the feeling of uncertainty and risk which negatively influences the probability to adopt (Gao & Bai, 2014). Extent technology adoption literature identified trust as a countermeasure in order to nurture a feeling of safety (Lin, 2011).

This thesis considers trust of consumers in IoT technology to play a pivotal factor in the decision making to adopt such technology. As a variable capable of promoting the adoption of innovative technology while at the same time diminishing the perceived

risk, a relationship between trust and BI is integrated in the TAM and proposed for testing. Therefore, it is hypothesised that:

> ***H3.*** *Trust has a significant and positive relationship with consumer decisions to adopt IoT technology.*

3.2.3.4 Social Influence

During the last decade, research about technology adoption frequently included a social component as well. While such research implemented either the already previously mentioned variable of SN from the TRA (Fishbein & Ajzen, 1975) or the variable of social influence which is adopted from the unified theory of acceptance and use of technology model (Venkatesh, Morris, Davis, & Davis, 2003), both variables have the same meaning. Although Davis (1996) decided against including social factors in the original TAM, it needs to be noted that the world, the technology, and the consequent possibilities have evolved since then. Nowadays, people are not solely influenced by others close to them (i.e. friends or family) but also by a much larger extent from strangers in the media (i.e. TV, blogs, or social media channels). Excluding social factors based on Davis' (1989) argumentation that it is highly unlikely that a person in the environment of the potential user has access to or experience with the technology under investigation is not reasonable anymore. Thanks to the Internet, users from all over the world can share their experiences and access this information, without being limited to a certain place or point of time anymore. Many people make use of such opinions and consider using a technology solely based on information they picked up in the media (Gao & Bai, 2014). Therefore, the social context should receive attention as well when researching the adoption of technology because it is an important component in the decision-making process (Chong et al., 2012; Gao & Bai, 2014; Hsu & Lu, 2004).

There is even a particularly greater impact of social influences on the adoption of technology when it was only recently introduced to the market because there is not much information about the product available yet. Thus, potential consumers rely on the opinion of their social network or other influencers they know from the media in order to evaluate the product (Gao & Bai, 2014; Yang et al., 2017). IoT technology in

the consumer sector qualifies as such new technology which makes it interesting to study further.

Previous research established a significant relationship between social influences and the adoption in the context of mobile commerce (Chong et al., 2012), smartphones (Chi et al., 2011), smart homes (Maddulety, Sharma, Venkatesh, & Seetharaman, 2017), smart home services (Yang et al., 2017), and ultimately IoT technology in general (Liew et al., 2017; Mital et al., 2016).
However, it must be noted that research regarding technology adoption of IoT technology applying social influence is scarce in comparison to how often the TAM was applied to research technology adoption. Thus, there is a need for further research. This thesis agrees with previous research and aims to contribute to filling that gap. Accordingly, it is hypothesised that:

> ***H4.*** *Social influence has a significant and positive relationship with consumer decisions to adopt IoT technology.*

4. Analysis and Findings

Within this fourth chapter, the findings of the data analysis with SPSS will be presented. Prior to the main findings, some more general results will be outlined as well as the previously mentioned Cronbach's *α* test and the respective values for the scale items.

4.1 Descriptive Data

Resulting from the online survey, a total of 193 responses were collected. After cleaning the data set according to the previously described criteria, a data set of 158 useable responses was qualified for the ensuing analysis. Research with a similar context as this thesis uses a similar sample size (Liew et al., 2017; Yang et al., 2017). The response rate was rather difficult to measure because the distribution took place on Facebook and SurveyCircle. Since both websites do not offer the possibility to get information about the actual reach of the post. Resulting from that, it is not possible to determine how many people actually saw the postings and the survey.

Table 2 below demonstrates the demographics of the data set. The gender of the respondents was almost equally distributed with a slight advantage for the female gender. Males accounted for 46.8 per cent (n = 74) of the sample while the female share was 53.2 per cent (n = 84). This distribution of gender is in accordance with similar research (H. Li, Wu, Gao, & Shi, 2016; Liew et al., 2017). This is also confirming with Gannon, Nothern and Carrol (1971) stating that females show a higher tendency to participate in surveys in comparison to males. Moreover, the age of respondents ranged from 18 to 70 years. However, the majority of the respondents were relatively young with an age between 25 and 34 (68.4 per cent). Based on the distribution channels, Facebook and SurveyCircle, this was expected because mainly younger people use these platforms. Lastly, the data set showed that 95.0 per cent (n = 150) of the participants of the study were of German nationality, followed by Austrian with 3.80 per cent (n = 6), and Swiss with 1.27 per cent (n = 2). Overall, it is reasonable to state that the respondents were highly educated since a majority of the sample either had a bachelor degree (38.6 per cent, n = 61) or master degree (34.18 per cent, n =

54) from university. It is also noteworthy to mention that all respondents indicated to have a medium to high knowledge about the topic of IoT.

Demographic Characteristics	*Demographic Sub-Characteristics*	*Frequency (n = 158)*	*Percentage (%)*
Gender	Male	74	46.84
	Female	84	53.16
Age	18 – 24	34	21.52
	25 – 34	108	68.35
	35 – 44	5	3.16
	> 44	11	6.96
Nationality	German	150	94.94
	Austrian	6	3.80
	Swiss	2	1.27
Education	Abitur	17	10.76
	Aprenticeship	19	12.03
	Bachelor	61	38.61
	Master	54	34.18
	Promotion	5	3.16

Table 2: Respondent Profile

4.2 Data Analysis

4.2.1 Reliability Analysis

Prior to the main part of the data analysis, the validity of the individual items of measurement was tested with Cronbach's *α*. The mean value of each construct, the standard deviation, as well as the respective Cronbach's *α* value can be seen in Table 3. The variables range from 0.756 to 0.872. The highest *α* value was seen for PEOU at 0.872 while the lowest one was seen for trust at 0.756. PU, social influence, and intention to adopt show *α* values of 0.781, 0.832, and 0.849 respectively. Consequently, all *α* values are above the cut off level of 0.700 and can be considered of high reliability.

Construct	*Number of Items*	*Cronbach's α*
Perceived usefulness	5	0.781
Perceived ease of use	5	0.872
Trust	4	0.756
Social influence	3	0.832
Intention to adopt	3	0.849

Table 3: Cronbach's *α* Values

4.2.2 Correlation Analysis

As a first step in the correlation analysis, the relationship between the individual variables were tested with the Pearson correlation coefficient *r*. The Pearson's *r* ranges from -1 to +1 indicating a negative or positive correlation between the tested variables. Relationships are stronger the closer *r* values are to ±1 while a value of 0 indicates no relationship at all. The respective values of Pearson's *r* from the variables used in this thesis are illustrated in Table 4. The results indicate that all items are positively correlated with the intention to adopt IoT technology. Trust shows the strongest correlation coefficient $r = 0.672$ with the intention to adopt. This correlation indicates that potential consumers of IoT technology need to trust IoT technology before they form an intention to adopt it. PEOU showed the lowest correlation to the intention to adopt with a correlation coefficient of $r = 0.385$. Additionally, social influence ($r = 0.524$) and PU ($r = 0.490$) are significantly correlated to the intention to adopt. Neither of the correlations is above 0.7 and all correlation between the variables showed $p < 0.05$ which makes them statistically significant. Consequently, multicollinearity can be excluded (Allen & Bennett, 2010; Field, 2009). Regarding the mean values of the variables, the values range from 3.352 (intention to adopt) to 3.799 (PU) on the Likert scale from 1 = strongly disagree to 5 = strongly agree. Based on these ratings, one can conclude that the participants of the study were neutral to slightly positive towards the variables tested within this thesis. The standard deviation ranged from 0.186 (PEOU) to 0.410 (trust).

Variables	*IA*	*PU*	*PEOU*	*T*	*SI*
IA	.				
PU	0.490*	.			
PEOU	0.385*	0.168*	.		
T	0.672*	0.468*	0.364*	.	
SI	0.524*	0.204*	0.353*	0.627*	.

**Correlation is significant at the 0.05 level

Table 4: Pearson's Correlation Matrix

4.2.3 Regression Analysis

After it was established that there is no multicollinearity between the variables, a multiple regression analysis was conducted and the results are illustrated in Table 5. With variance inflation factor (VIF) values between 1.188 and 2.115, all variables are well below the recommended cut off value of 10. Additionally, the tolerance values are between 0.473 and 0.842 which is above the recommended minimum level of 0.100. Both the VIF and tolerance values support the absence of multicollinearity.

Based on the results shown in Table 5, the overall model shows a strong correlation (R = 0.729) between the predicted and actual values. Referring to Cohen (1988), R^2 = 0.532 and R^2_{adj} = 0.520 indicate a high goodness-of-fit for the model created in this thesis.

PU (β_2 = 0.246, t = 3.897, p < 0.05), PEOU (β_2 = 0.137, t = 2.273, p < 0.05), trust (β_2 = 0.395, t = 4.912, p < 0.05), and social influence (β_2 = 0.178, t = 2.451, p < 0.05) show a positive relationship to the intention to adopt IoT technology. Additionally, all relationships are statistically significant because all p values are below 0.05.

In addition, a linear regression analysis was carried out to investigate the relationship between PEOU and PU (Table 6). The results indicate that PEOU has a positive relationship to PU (β_2 = 0.168, t = 2.131, p < 0.05). However, this model only had a low goodness-of-fit with R^2 = 0.028 and R^2_{adj} = 0.022 (Cohen, 1988).

Based on these findings, this thesis accepts the proposed hypotheses H1-4. Moreover, it can be noted that trust is the most influential factor on consumer's intention to adopt IoT technology. The entire SPSS output can also be found in Appendices 5 and 6.

	R	R^2	R^2_{adj}	*F*	*B*	*SE*	β_2	*t*	*VIF*
*Constant**	0.729	0.532	0.520	43.497	- 1.521	0.559		-2.724	
PU*					0.428	0.110	0.246	3.897	1.303
PEOU*					0.301	0.133	0.137	2.273	1.188
T*					0.394	0.080	0.395	4.912	2.115
SI*					0.179	0.073	0.178	2.451	1.727

*Correlation is significant at the 0.05 level

Table 5: Results of Multiple Linear Regression Analysis

	R	R^2	R^2_{adj}	*F*	*B*	*SE*	β_2	*t*
*Constant**	0.168	0.028	0.022	4.541	2.996	0.377		7.946
PEOU*					0.212	0.100	0.168	2.131

*Correlation is significant at the 0.05 level

Table 6: Results of Linear Regression Analysis

5. Discussion

5.1 Conclusion

The aim of this thesis was to research the relationship between factors and the intention to adopt IoT technology via an extension of the TAM. Based on the linear and multiple regression analysis, all hypotheses were supported. Thus, PU, PEOU, trust, as well as social influence were identified to have a positive relationship with the intention to adopt IoT technology.

PU was identified to have the second greatest influence on the intention to adopt IoT technology (β_2 = 0.246, t = 3.897, p < 0.05). Thus, H1 was supported. From the findings, one can derive that potential consumers evaluate IoT technology as useful in their life. The responses show that the respondents concur with IoT technology being helpful, time saving, and improving the execution of their daily task. This is in accordance with the findings from previous research (Gao & Bai, 2014; Liew et al., 2017; Mital et al., 2016; Shin et al., 2018) showing that PU is a critical determinant positively influencing behavioural intentions such as the intention to adopt IoT technology.

Moreover, this thesis found PEOU to influence the intention to adopt IoT technology both positively and statistically relevant (β_2 = 0.137, t = 2.273, p < 0.05). Based on this finding, H2a is confirmed. Again, this relationship is in accordance with other research in similar fields (Gao & Bai, 2014; Liew et al., 2017; Mital et al., 2016; Shin et al., 2018) manifesting the importance of PEOU in the adoption of new technology. This finding indicates that a multiplicity of potential consumers of IoT technology is well-versed when it comes to new technologies and that they feel like they are able to operate such technology with ease. PEOU was additionally identified to have a positive influence on PU (β_2 = 0.168, t = 2.131, p < 0.05) which supports H2b. The influence of PEOU on PU indicates that IoT products need to be user friendly since they appear to be more useful when they are also easy to use.

Trust was found to be the most influential determinant affecting the intention to adopt IoT technology (β_2 = 0.395, t = 4.912, p < 0.05) which supports H3. Based on this finding, one can deduct that potential consumers need to trust IoT technology first

before they consider adopting it. This strong relationship is in accordance with previous research on the field of technology adoption (Lin, 2011).

Lastly, social influence was also identified as a positive determinant of the intention to adopt IoT technology ($\beta_2 = 0.178$, $t = 2.451$, $p < 0.05$) and H4 is accepted. Despite showing the weakest relationship to the intention to adopt IoT technology, the findings still indicate that potential consumers rely on their social surroundings (friends and family) but also on the media. This finding corresponds with other research (Hsu & Lu, 2004) stating social influence to be a vital factor in the decision making of consumers.

5.2 Managerial Implications

Managers of IoT technology companies can take away many important learnings from this thesis. To begin with, German consumers are very sensitive to trust because it was identified as a crucial factor influencing the intention to adopt IoT technology. Previous research (Gao & Bai, 2014; Liew et al., 2017) frequently identified PU as the most important driver to technology adoption. This demonstrates how diverse markets can be and that it is important to conduct country-specific research in order to identify the needs of a specific market, for instance before entering it. Since IoT technology is a very invasive product that collects data of its users continuously, IoT companies need to assure that all collected data is secured to the highest standards and not abused. Thus, IoT companies are well advised to educate consumers about the measurements that were taken to protect for instance their privacy. Additionally, consumers do not only need to take the passive role of gathering information from companies but can also be encouraged to engage with trust building actions in the form of regular invitations to check and adjust the privacy settings of the IoT technology. Being reflective and open about trust issues can be a differentiator in a competitive market.

Besides, the perception of how useful IoT technologyis should not be neglected. IoT companies should not fail to convey the message that this technology is more than just a gimmick but can create real additional value. There are different target groups that carefully need to be identified and addressed. While controlling lights or checking if the windows are closed via voice commands and smartphones may sound playful for some users, but this can be a an indispensable facilitation of the everyday life of users with

disabilities and limited movement. Thus, it is recommended to create more diverse messages about the usefulness of IoT technology.

Ultimately, the findings additionally indicate that consumers are influenced by their social environment in their decision-making. There is little influence that companies can take on the family and friends of consumers but they now have a great opportunity to interact with consumers through diverse media channels. Especially social media represents a great chance because actual users of a product can share their real and honest opinion. Using a technology influencer to test and present IoT products could potentially be more convincing than information created by the company. Moreover, such influencers could create a synergy effect because they have the power to show the usefulness of IoT technology in their private life, which could aid in creating an improved perception of technology's usefulness.

All in all, this thesis demonstrated that PU, PEOU, trust, and social influence directly influence the intention to adopt IoT technology. Against this background, the researcher of this thesis recommends IoT companies to focus on measurements to make consumers trust their products as well as demonstrate more clearly how and why IoT technology is a useful extension to the everyday life.

5.3 Limitations & Future Research

Just like any research, the underlying one is not free of limitations. To begin with, this thesis applied a convenience sample method which collected data from a sample that did not represent the entire German population. A better and more valid understanding of the German population could have been achieved when applying a probability sampling method. To a great extent, respondents of the study were of a relatively young age (25-34 years). Since people of this age range grew up with technology, this may have had an impact on the overall positive evaluation of the different determinants of the intention to adopt IoT technology. Additionally, respondents of the study were only presented with IoT technology in general instead of specific cases. Results may differ when respondents are presented with IoT technology from different product categories or price ranges.

A great opportunity for future research could be a longitudinal study about the intention to adopt IoT technology. It could be of interest to investigate how many of the people how indicated that they intend to adopt IoT technology actually act upon their intention and adopt. Additionally, one of the main findings of this thesis is that trust plays a crucial role in the decision-making process to adopt IoT technology. Future research can aim to replicate and validate the findings of the research at hand with different IoT technologies or within different country contexts. Moreover, additional research could be conducted to investigate if and how the determinants differ in the context of specific IoT technology. Doing so would help to better comprehend the influence of the determinants on the intention to adopt various IoT technology. Lastly, it is advisable to replicate the research with a larger sample that better represents the German population. Most of the findings are based on answers of respondents aged 18-35 while the other age groups only represent a relatively small part of the research. Findings based on a more distributed sample could potentially have an influence on the factor PEOU as older generations are not digital natives such as the majority of the sample used in this research. However, the recently introduced changes in European data policies laws could also have an impact on the findings. Comparing the findings of this thesis with ones from respondents that have been exposed to these regulations for a longer period of time could also be an interesting field for future research.

Bibliography

Aalborg University Library. (2018). Databases and Suppliers. Retrieved September 5, 2018, from http://www.en.aub.aau.dk/find-material/databases/#dbletter-S

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl & J. Beckmann (Eds.), *Action Control: From Cognition to Behavior. SSSP Springer Series in Social Psychology* (pp. 11–39). Berlin: Springer.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Alarcon, D. (2015). Here's why the Internet of Things has been compared to the Industrial revolution. Retrieved November 7, 2018, from https://www.itproportal.com/2015/05/31/heres-why-internet-of-things-compared-industrial-revolution/

Allen, P., & Bennett, K. (2010). *PASW Statistics by SPSS: A practical guide: version 18.0*. Nelson Australia.

Alomary, A., & Woollard, J. (2015). How Is Technology Accepted by Users? A Review of Technology Acceptance Models and Theories. In *Proceedings of The IRES 17th International Conference, London, United Kingdom, 21st November 2015*. Retrieved from https://www.researchgate.net/publication/285232643_How_Is_Technology_Accepted_by_Users_A_Review_of_Technology_Acceptance_Models_and_Theories

Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. *Computer Networks*, *54*(15), 2787–2805.

Atzori, L., Iera, A., & Morabito, G. (2014). From "smart objects" to "social objects": The next evolutionary step of the internet of things. *IEEE Communications Magazine*, *52*(1), 97–105.

Bae, Y., & Chang, H. (2012). Adoption of smart TVs: a Bayesian network approach. *Industrial Management & Data Systems*, *112*(6), 891–910.

Bagozzi, R. (2007). The Legacy of the Technology Acceptance Model and a Proposal for a Paradigm Shift. *Journal of the Association for Information Systems*, *8*(4), 244–254.

Balta-Ozkan, N., Boteler, B., & Amerighi, O. (2014). European smart home market development: Public views on technical and economic aspects across the United

Kingdom, Germany and Italy. *Energy Research and Social Science*, *3*, 65–77.

BCS The Chartered Institute for IT. (2017). *The Internet of Things: Living in a connected world*. BCS Learning & Development Limited.

Broughall, N. (2014). Jawbone UP Move | TechRadar. Retrieved October 30, 2018, from https://www.techradar.com/reviews/gadgets/jawbone-up-move-1277383/review

Bryman, A. (1988). *Quantity and Quality in Social Research*. London: Routledge.

Bryman, A., & Bell, E. (2011). *Business Research Methods* (3rd ed.). Oxford University Press.

Burrell, G., & Morgan, G. (1979). *Sociological Paradigms and Organisational Analysis - Elements of the Sociology of Corporate Life*. London: Heinemann.

Chang, Y., Dong, X., & Sun, W. (2014). Influence of Characteristics of the Internet of Things on Consumer Purchase Intention. *Social Behavior and Personality: An International Journal*, *42*(2), 321–330.

Chi, H., Yeh, H. R., & Yang, Y. (2011). Applying Theory of Reasoned Action and Technology Acceptance Model to Investigate Purchase Behavior on Smartphone. *Journal of International Management Studies*, *6*(3), 1–11.

Chikhaoui, B., & Pigot, H. (2010). Towards analytical evaluation of human machine interfaces developed in the context of smart homes. *Interacting with Computers*, *22*(6), 449–464.

Cho, Y. C., & Sagynov, E. (2015). Exploring Factors That Affect Usefulness, Ease Of Use, Trust, And Purchase Intention In The Online Environment. *International Journal of Management & Information Systems*, *19*(1), 21–36.

Chong, A. Y.-L., Chan, F. T. S., & Ooi, K.-B. (2012). Predicting consumer decisions to adopt mobile commerce: Cross country empirical examination between China and Malaysia. *Decision Support Systems*, *53*(1), 34–43.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, N.J.: L. Erlbaum Associates.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (4th ed.). London: Sage.

Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. London: Sage.

Daniel, J. (2012). *Sampling essentials: Practical guidelines for making sampling choices*. Los Angeles: Sage.

Danson, M., & Arshad, N. (2014). The Literature Review. In K. O'Gorman & R. MacIntosh (Eds.), *Research Methods for Business & Management: A Guide to Writing Your Dissertation* (pp. 37–57). Oxford: Goodfellow Publishers Ltd.

Davis, F. D. (1985). *A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results*. MIT Sloan School of Managment.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *Management Information System Research Center*, *13*(3), 319–340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003.

De Vaus, D. (2001). *Research Design in Social Research*. London: Sage.

Dixon-Woods, M., Agarwal, S., Jones, D., Young, B., & Sutton, A. (2005). Synthesising Qualitative and Quantitative Evidence: A Review of Possible Methods. *Journal of Health Services Research & Policy*, *10*(1), 45–53.

Dodgson, M., Gann, D., & Salter, A. J. (2008). *The Management of Technological Innovation: Strategy and Practice* (2 Rev. ed.). United Kingdom: Oxford University Press.

Dormehl, L. (2014). Internet of Things: it's all coming together for a tech revolution. Retrieved November 7, 2018, from https://www.theguardian.com/technology/2014/jun/08/internet-of-things-coming-together-tech-revolution

European Commission. (2014). *Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination*. Retrieved from https://ec.europa.eu/digital-agenda/en/news/definition-research-and-innovation-policy-leveraging-cloud-computing-and-iot-combination

Evans, D. (2011). *The Internet of Things*. *Cisco Blogs*. Retrieved from https://blogs.cisco.com/diversity/the-internet-of-things-infographic

Fayad, R., & Paper, D. (2015). The Technology Acceptance Model E-Commerce Extension: A Conceptual Framework. *Procedia Economics and Finance*, *26*, 1000–1006. https://doi.org/10.1016/s2212-5671(15)00922-3

Field, A. P. (2009). *Discovering Statistics using SPSS* (3rd ed.). London: Sage.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research.* Reading, MA: Addison-Wesley.

Fishbein, M., & Ajzen, I. (2005). The Influence of Attitudes on Behavior. In D. Albarracín, B. T. Johnson, & M. P. Zanna (Eds.), *The Handbook of Attitudes* (pp. 173–221). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Friedewald, M., Da Costa, O., Punie, Y., Alahuhta, P., & Heinonen, S. (2005). Perspectives of ambient intelligence in the home environment. *Telematics and Informatics*, *22*(3), 221–238.

Gannon, M. J., Nothern, J. C., & Carroll, S. J. (1971). Characteristics of nonrespondents among workers. *Journal of Applied Psychology*, *55*(6), 586–588.

Gao, L., & Bai, X. (2014). A unified perspective on the factors influencing consumer acceptance of internet of things technology. *Asia Pacific Journal of Marketing and Logistics*, *26*(2), 211–231.

Garun, N. (2016). Amazon just launched a cashier-free convenience store. Retrieved April 15, 2019, from https://www.theverge.com/2016/12/5/13842592/amazon-go-new-cashier-less-convenience-store

Gill, J., & Johnson, P. (2002). *Research Methods for Managers* (3rd ed.). London: Sage.

Goffin, K. (1998). Evaluating Customer Support During New Product Development - An Exploratory Study. *Journal of Product Innovation Management*.

Goode, L. (2018). Apple Watch 4 Adds ECG, EKG, and More Heart-Monitoring Capabilities. Retrieved October 9, 2018, from https://www.wired.com/story/apple-watch-series-4/

Google Trends. (2018). Internet der Dinge - Erkunden - Google Trends. Retrieved October 29, 2018, from https://trends.google.com/trends/explore?date=all&q=%2Fm%2F02vnd10

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.). Harlow: Pearson Education Ltd.

Holden, R. J., & Karsh, B.-T. (2010). The Technology Acceptance Model: Its past and its future in health care. *Journal of Biomedical Informatics*, *43*(1), 159–172.

Hsu, C.-L., & Lu, H.-P. (2004). Why do people play on-line games? An extended TAM with social influences and flow experience. *Information and Management*, *41*(7), 853–868.

Institute for Digital Research and Education. (2017). What is the difference between categorical, ordinal and interval variables? Retrieved September 5, 2018, from https://stats.idre.ucla.edu/other/mult-pkg/whatstat/what-is-the-difference-

between-categorical-ordinal-and-interval-variables/

ITU-T Y.2060. (2012). Next Generation Networks - Frameworks and functional architecture models: Overview of the Internet of things. In *Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks*.

Jesson, J., Matheson, L., & Lacey, F. M. (2011). *Doing Your Literature Review: Traditional and Systematic Techniques*. London: SAGE Publications Ltd.

Katz, M. L., & Shapiro, C. (1985). Network Externalities, Competition, and Compatibility. *The American Economic Review*, *75*(3), 424–440.

Kuada, J. (2012). *Research Methodology - A Project Guide for University Students*. Samfundslitteratur Press.

Kumar, R. (2011). *Research Methodology: A Step-by-Step Guide for Beginners* (3rd ed.). London: Sage.

Lee, I., Choi, B., Kim, J., & Hong, S.-J. (2007). Culture-Technology Fit: Effects of Cultural Characteristics on the Post-Adoption Beliefs of Mobile Internet Users. *International Journal of Electronic Commerce*, *11*(4), 11–51.

Lee, Y.-K., Park, J.-H., Chung, N., & Blakeney, A. (2012). A unified perspective on the factors influencing usage intention toward mobile financial services. *Journal of Business Research*, *65*(11), 1590–1599.

Lee, Y. K., Batina, L., & Verbauwhede, I. (2010). Privacy Challenges in RFID Systems. In D. Giusto, A. Iera, G. Morabito, & L. Atzori (Eds.), *The Internet of Things: 20th Tyrrhenian Workshop on Digital Communications* (pp. 397–407). New York: Springer.

Li, H., Wu, J., Gao, Y., & Shi, Y. (2016). Examining individuals' adoption of healthcare wearable devices: An empirical study from privacy calculus perspective. *International Journal of Medical Informatics*, *88*(555), 8–17.

Li, W., Lee, Y.-H., Tsai, W.-T., Xu, J., Son, Y.-S., Park, J.-H., & Moon, K.-D. (2012). Service-oriented smart home applications: composition, code generation, deployment, and execution. *Service Oriented Computing and Applications*, *6*, 65–79.

Liew, C. S., Ang, J. M., Goh, Y. T., Koh, W. K., Tan, S. Y., & Teh, R. Y. (2017). *Factors influencing consumer acceptance of internet of things technology*. *The Internet of Things: Breakthroughs in Research and Practice*. https://doi.org/10.4018/978-1-5225-1832-7.ch004

Lin, H. F. (2011). An empirical investigation of mobile banking adoption: The effect of innovation attributes and knowledge-based trust. *International Journal of Information Management*, *31*(3), 252–260.

Lu, Y., Papagiannidis, S., & Alamanos, E. (2018). Internet of Things: A systematic review of the business literature from the user and organisational perspectives. *Technological Forecasting and Social Change*.

Luukkonen, S., Sovie, D., Curran, J., Björnsjö, A., Viglino, M., & Lovati, G. (2016). *Igniting Growth in Consumer Technology*. *Accenture*.

Madden, T. J., Ellen, P. S., & Ajzen, I. (1992). A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action. *Personality and Social Psychology Bulletin*, *18*(1), 3–9.

Maddulety, K., Sharma, S., Venkatesh, K. P., & Seetharaman, A. (2017). Factors Influencing Purchase of Smart Appliances in Smart Homes. *Journal of Accounting, Business & Management*, *24*(1), 21–42.

Mani, Z., & Chouk, I. (2017). Drivers of consumers' resistance to smart products. *Journal of Marketing Management*, *33*(1–2), 76–97.

Manyika, J., Chui, M., Bisson, P., Woetzel, J., Dobbs, R., Bughin, J., & Aharon, D. (2015). *The Internet of Things: Mapping the value beyond the hype*. *McKinsey Global Institute*.

Mathieson, K. (1991). Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior. *Information Systems Research*, *2*(3), 173–191.

Medaglia, C. M., & Serbanati, A. (2010). An Overview of Privacy and Security Issues in the Internet of Things. In D. Giusto, A. Iera, G. Morabito, & L. Atzori (Eds.), *The Internet of Things: 20th Tyrrhenian Workshop on Digital Communications* (pp. 389–395). New York: Springer.

Miller, A. (2017). Welcome to the Smart Home Ecosystem | Vector Security. Retrieved April 15, 2019, from https://www.vectorsecurity.com/blog/welcome-to-the-smart-home-ecosystem

Miller, M. (2015). *The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World*. *Online Searcher* (Vol. 39). Indianapolis: Que.

Miorandi, D., Sicari, S., De Pellegrini, F., & Chlamtac, I. (2012). Internet of things: Vision, applications and research challenges. *Ad Hoc Networks*, *10*(7), 1497–

1516.

Mital, M., Choudhary, P., Chang, V., Papa, A., & Pani, A. K. (2016). Adoption of Internet of Things in India: A test of competing models using a structured equation modeling approach. *Technological Forecasting and Social Change*, *136*, 339–346.

Nest. (2018a). Learn how to control your Nest products with Amazon Alexa. Retrieved October 18, 2018, from https://nest.com/support/article/Nest-and-Amazon-Alexa?from-chooser=true

Nest. (2018b). Nest Thermostat E | Overview. Retrieved October 9, 2018, from https://nest.com/thermostats/nest-thermostat-e/overview/

Noblit, G. W., & Hare, R. D. (1988). *Meta-Ethnography: Synthesising Qualitative Studies*. *Sage University Paper Series on Qualitative Research Methods* (Vol. 11). London: SAGE Publications.

Olenski, S. (2014). 5 Inexpensive Ways To Promote A Product Launch. Retrieved October 30, 2018, from https://www.forbes.com/sites/steveolenski/2014/10/14/5-inexpensive-ways-to-promote-a-product-launch/#3dc2d7142eeb

Papaioannou, D., Sutton, A., Carroll, C., Booth, A., & Wong, R. (2009). Literature Searching for Social Science Systematic Reviews: Consideration of a Range of Search Techniques. *Health Information and Libraries Journal*, *27*(2), 114–122.

Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the Social Sciences: A Practical Guide*. Oxford: Blackwell Publishing Ltd.

Philips Hue. (2018). Amazon Alexa - Hue. Retrieved October 9, 2018, from https://www2.meethue.com/de-de/friends-of-hue/amazon-alexa

Pope, C., Mays, N., & Popay, J. (2007). *Synthesising Qualitative and Quantitative Health Research: A Guide to Methods*. *Open University Press*. Maidenhead: McGraw-Hill Education.

Qasim, H., & Abu-Shanab, E. (2016). Drivers of mobile payment acceptance: The impact of network externalities. *Information Systems Frontiers*, *18*(5), 1021–1034.

ResearchGate. (2014). ResearchGate discussion: Likert scale. Retrieved September 5, 2018, from https://www.researchgate.net/post/Is_a_Likert-type_scale_ordinal_or_interval_data

ResearchGate. (2015). ResearchGate discussion: 5 or 7 point Likert scale. Retrieved July 25, 2018, from https://www.researchgate.net/post/Should_we_use_a_5_or_7_point_Likert_scal

e_Whats_better_and_why

Rialle, V., Duchene, F., Noury, N., Bajolle, L., & Demongeot, J. (2002). Health “Smart” Home: Information Technology for Patients at Home. *Telemedicine Journal and E-Health*, *8*(4), 395–409.

Rogers, E. M. (1983). *Diffusion of innovation: a cross-cultural approach*. New York: The Free Press.

Rogers, E. M. (1995). *The Diffusion of Innovation*. New York: The Free Press.

Rogers, E. M. (2003). *Diffusion of Innovations,* (5th ed.). New York: Free Press.

Samaradiwakara, G. D. M. N., & Gunawardena, C. G. (2014). Comparison of existing technology acceptance theories and models to suggest a well improved theory/model. *International Technical Sciences Journal*, *1*(1), 21–36.

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students* (5th ed.). Harlow: Prentice Hall.

Shah, S. R. (2014). Smartphone healthcare: technology comes with caution! *Perspectives in Public Health*, *134*(6), 320–320.

Shin, J., Park, Y., & Lee, D. (2018). Who will be smart home users? An analysis of adoption and diffusion of smart homes. *Technological Forecasting and Social Change*, *134*, 246–253.

Snilstveit, B., Oliver, S., & Vojtkova, M. (2012). Narrative approaches to systematic review and synthesis of evidence for international development policy and practice. *Journal of Development Effectiveness*, *4*(3), 409–429.

Sommerville, H. (2017). Jawbone’s demise a case of “death by overfunding” in Silicon Valley | Reuters. Retrieved October 30, 2018, from https://www.reuters.com/article/us-jawbone-failure/jawbones-demise-a-case-of-death-by-overfunding-in-silicon-valley-idUSKBN19V0BS

Statista. (2018a). IoT: number of connected devices worldwide 2012-2025.

Statista. (2018b). Smart Home - worldwide. Retrieved October 8, 2018, from https://www-statista-com.zorac.aub.aau.dk/outlook/279/100/smart-home/worldwide?currency=usd

Statista. (2018c). Smart Home Report 2018, (September), 119.

Stringer, M., Fitzpatrick, G., & Harris, E. (2006). Lessons for the Future: Experiences with the Installation and Use of Today’s Domestic Sensors and Technologies Mark. In K. P. Fishkin, B. Schiele, P. Nixon, & A. Quigley (Eds.), *4th International Conference, PERVASIVE 2006, Dublin, Ireland, May 7-10, 2006, Proceedings*

(pp. 383–399). Berlin, Heidelberg: Springer-Verlag.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, *22*, 960–967.

Ukil, A., Bandyoapdhyay, S., Puri, C., & Pal, A. (2016). IoT Healthcare Analytics: The Importance of Anomaly Detection. In *2016 IEEE 30th International Conference on Advanced Information Networking and Applications* (pp. 994–997). IEEE.

Ur Rehman, U., Rizwan, M., Ud din Ahmed, A., Ali, N., & Khan, M. H. (2013). E-TAM Model : A Comprehensive Approach to Understand the Adoption of Electronic Shopping. *Journal of Basic and Applied Scientific Research*, *3*(11), 178–188.

Venkatesh, Morris, Davis, & Davis. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425.

Venkatesh, V., & Davis, F. D. (1996). A Model of the Antecedents of Perceived Ease of Use: Development and Test. *Decision Sciences*, *27*(3), 451–481.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, *46*(2), 186–204.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly*, *36*(1), 157–178.

Wang, H., Zhang, T., Quan, Y., & Dong, R. (2013). Research on the framework of the Environmental Internet of Things. *International Journal of Sustainable Development and World Ecology*, *20*(3), 199–204.

Weber, R. H. (2015). Internet of things: Privacy issues revisited. *Computer Law and Security Review*, *31*(5), 618–627.

Webster, J., & Watson, R. T. (2016). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quaterly*, *26*(2).

Wu, W.-Y., & Ke, C.-C. (2015). An Online Shopping Behavior Model Integrating Personality Traits, Perceived Risk, and Technology Acceptance. *Social Behavior and Personality: An International Journal*, *43*(1), 85–97.

Yang, H., Lee, H., & Zo, H. (2017). User acceptance of smart home services: An extension of the theory of planned behavior. *Industrial Management and Data Systems*, *117*(1), 68–89.

Yi, M. Y., Jackson, J. D., Park, J. S., & Probst, J. C. (2006). Understanding information technology acceptance by individual professionals: Toward an integrative view.

Information and Management, *43*(3), 350–363.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). Los Angeles City: SAGE Publications.

Yonck, R. (2013). Connecting with Our Connected World | World Future Society. *The Futurist*, *November-D*, 16–21.

Yousafzai, S. Y., Foxall, G. R., & Pallister, J. G. (2010). Explaining Internet Banking Behavior: Theory of Reasoned Action, Theory of Planned Behavior, or Technology Acceptance Model? *Journal of Applied Social Psychology*, *40*(5), 1172–1202.

Ziamou, P. (2002). Commercializing new technologies: Consumers' response to a new interface. *Journal of Product Innovation Management*, *19*(5), 365–374. https://doi.org/10.1016/S0737-6782(02)00153-4

Zikmund, W. G. (2003). *Business Research Methods* (7th ed.). Ohio: South-Western.

Appendix

Appendix 1: Literature Selection Process

	References	*Excluded*	*Included*
Conventional Subject Searching	6,938	-	-
Post Search Criteria Application	1,043	5,895	-
References Post Title, Abstract & Keyword Sift	83	960	-
References Post Full-Text Sift	35	48	-
References Post Back- & Forward Searching	52	-	17
Data Synthesis	52	-	-

Appendix 2: Literature Review Evidence Table

Author(s)	*Year*	*Method*	*Participants*	*Research Focus*	*Keywords*	*Findings*
Alomary & Woollard	2015	Literature Review	-	This paper provides a literature review of the popular theories and models of technology acceptance of relevance to today's technology developments in the 4E context.	E-Education; E-Learning; Epistemology; Information Technology; perceptions; technology acceptance	The flexibility of TAM to be extended and modified to take into account other relevant factors makes it a powerful framework. This paper identifies the underpinning theories and potential application in a concise way and concludes that TAM has and will provide underpinning for further understanding of the pedagogy-technology- epistemology relationship in the development of technology use.
Atzori et al.	2010	Literature review	-	The paper addresses the Internet of Things paradigm and aims to contribute to the advance of this concept.	Internet of Things; pervasive computing; RFID systems	Current technologies make the IoT concept feasible but do not fit well with the scalability and efficiency requirements they will face. We believe that, given the interest shown by industries in the IoT applications, in the next years addressing such issues will be a powerful driving factor for networking and communication research in both industrial and academic laboratories
Bae & Chang	2012	Survey	316	This study aims to identify factors that determine the smart TV buying decisions of users and analyse the relationships among the factors.	Consumer behaviour; decision making; buying behaviour; television; smart TV; innovation diffusion theory; Bayesian network	The results show that relative advantage has the greatest influence on the purchase intention of smart TV, followed by compatibility, entertainment, web-browsing and n-screen.
Bagozzi	2007	Literature Review	-	In this commentary, I attempt to point out limitations with the Technology Acceptance Model (TAM) and lay the groundwork for an alternative approach for studying information technology adoption/acceptance/rejection.	TAM; UTAUT; paradigm shift	TAM is a remarkable model and has had an incredible effect on empirical research for a long time. But it seems to have reached a turning point. On the one hand, it is too simple and leaves out important variables and processes. On the other hand, recent extensions of TAM (e.g., the UAUT) have been a patchwork of many largely unintegrated and uncoordinated abridgements.
Balta-Ozkan et al.	2014	Literature Review	-	The aim of this paper is to illustrate differences and similarities in technical and economic drivers and barriers to smart home market development in three European countries characterized by different policy and socio-economic contexts.	Smart home; European smart home market; Public views; Smart energy system	The research reveals key barriers to the adoption of smart homes such as reliability, data privacy, and costs of smart home technologies across the countries studied. On the other hand, housing stock characteristics, both age of buildings and tenure, reveal deeper cross- country differences in attitudes and perceptions towards these technologies.

						The research highlights the need for smart home services that go beyond energy consumption and management services. Only when such a holistic approach is adopted, where other applications such as health or security, suited to the householders' needs and making positive contribution to their daily lives, are enabled, will the benefits of smart homes become clear to the consumer
Chi et al.	2011	Survey	282	Cell phone has become a popular product in recent years because of the high popularity of mobile communication. Not only is users' age decreasing but also it is an indispensable product in one's daily life. Therefore, this study applied theory of reasoned action and technology acceptance model to investigate the behavioural intention of smartphone users.	Smart phone; Theory of Reasoned Action; Technology Acceptance Model; behavioural intention	The major findings of this study are as follows: (1) perceived ease of use has a significant and positive effect on perceived usefulness and consumer's attitude respectively, (2) perceived usefulness has a significant and positive effect on consumer's attitude, (3) both consumer's attitude and subjective norm have a significant and positive effect on behavioural intention respectively, (4) perceived risk has a significant and positive effect on behavioural intention, and perceived value has a significant and positive effect on purchase intention, (5) perceived usefulness has a partial meditating effect between perceived ease of use and purchase intention behaviour; behavioural intention has a partial meditating effect between subjective norm and purchase intention; and behavioural intention and perceived value have no meditating effect between perceived risk and purchase intention.
Chikhaoui & Pigot	2010	Experimental study	10	This paper presents a study of user performance on two principal tasks of the contextual assistant's interface, developed in the context of smart homes, to assist persons with cognitive disabilities.	HMI evaluation; Human-computer interaction; Cognitive modelling; Smart homes; User modelling; User performance	The results show that, all models give a good prediction of user performance, even if the cognitive models show better accuracy of the user performance. Furthermore, they provide a better insight into cognitive abilities required to interact with the interface.
Cho & Sagynov	2015	Survey	216	Various studies have examined the effects of factors on online attitudes and behaviour. By applying the Technology Acceptance Model, this study is focused on investigating factors that affect customers' online purchasing behaviour.	Product Information; Price; Convenience; Product and Service Quality; Salesperson; Perceived Usefulness; Perceived Ease of Use; Trust; Intention to Purchase	The results of this study indicate that perceived usefulness, perceived ease of use, and trust had a statistically significant effect on behavioural intention to shop on the Internet.
Chong et al.	2012	Survey	394	This study aims to investigate the factors that predict consumer intention to adopt m-commerce in Malaysia and China.	M-commerce; Technology acceptance model (TAM); consumer	The results showed that age, trust, cost, social influence, and variety of services are able to predict Malaysian consumer decisions to adopt m-commerce. Trust, cost, and social

					behaviour; hierarchical regression analysis	influence can be used to predict Chinese consumer decisions to adopt m-commerce. This research confirms the need to extend the traditional TAM and DOI models when studying technology such as m-commerce.
Fayad & Paper	2015	Literature Review	-	In this study, we suggest the extension of the TAM for its application in the E-commerce field.	Technology Acceptance Model; User Satisfaction; Process Satisfaction; Outcome Satisfaction; Intentions; Actual Behaviour; Behavioural Expectations; E-commerce	Since there is a plethora of TAM studies, what is the value of one more? If a new TAM study measured actual behaviour as per the recommendation of Davis (1989), it would address one of the limitations of the original TAM and potentially confirm its robustness. In addition, if such a study applied the TAM in a different environment than the original, it would potentially provide more evidence of the TAM's generalizability.
Friedewald et al.	2005	Literature review	-	Will Ambient Intelligence fulfil the promises or is it just an illusion—offering apparently easy living while actually increasing the complexity of life? This article touches upon this question by discussing the technologies, applications and social implications of ambient intelligence in the home environment. It explores how Ambient Intelligence may change our way of life.	Ambient intelligence; House automation; Information society; Smart home; Ubiquitous computing	The article concludes that there are great opportunities for Ambient Intelligence to support social developments and modern lifestyles. However, in order to gain wide acceptance a delicate balance is needed: the technology should enhance the quality of life but not be seeking domination. It should be reliable and controllable but nevertheless adaptive to human habits and changing contexts.
Gao & Bai	2014	Survey	368	The current research aims to develop and test an integrative model of factors determining consumers' acceptance of IoT technology.	Information systems; innovation diffusion; hybrid intelligent business systems; innovation adoption behaviour; RFID application to logistic	The results showed particularly strong support for the effects of perceived usefulness, perceived ease of use, social influence, perceived enjoyment, and perceived behavioural control. However, trust played an insignificant role in predicting the intention. In addition, perceived ease of use and trust were found to affect perceived usefulness.
Holden & Karsh	2010	Literature review	-	Increasing interest in end users' reactions to health information technology (IT) has elevated the importance of theories that predict and explain health IT acceptance and use. This paper reviews the application of one such theory, the Technology Acceptance Model (TAM), to health care. We	Behaviour; Health information technology; Technology Acceptance Model; Technology use	Findings show that TAM predicts a substantial portion of the use or acceptance of health IT, but that the theory may benefit from several additions and modifications. Aside from improved study quality, standardization, and theoretically motivated additions to the model, an important future direction for TAM is to adapt the model specifically to the health care context, using beliefs elicitation methods.
Hsu & Lu	2004	Survey	233	On-line games have been a highly profitable e-commerce application in recent years. The market value of on-line games is increasing markedly and number of players is rapidly growing. The reasons that people play on-line games is an important area of research. This study views on-line games as entertainment technology. However,	On-line game; TAM; Social influence; Flow experience	Overall, the results reveal that social norms, attitude, and flow experience explain about 80% of game playing.

				while most past studies have focused on task-oriented technology, predictors of entertainment-oriented technology adoption have seldom been addressed.		
Lee et al.	2007	Survey	5121	Little is known about how culture affects users' perceptions and beliefs after they have adopted an information technology (IT). This study constructed and verified a research model, based on interaction theory and the cultural lens model, that focuses on the relationship between users' cultural profiles and post-adoption beliefs in the context of the mobile Internet.	Cultural lens, culture, culture-technology fit, interaction theory, mobile Internet, post-adoption, technology adoption	The results of large-scale on-line surveys in Korea, Hong Kong, and Taiwan indicate that four cultural factors—uncertainty avoidance, individualism, contextuality, and time perception—have a significant influence on users' post-adoption perceptions of mobile Internet services.
Lee et al.	2012	Literature review	-	This research proposes that the factors influencing the intention to use mobile financial services (MFS) include general technology perceptions, technology-specific perceptions, user characteristics, and task-user characteristics. Most previous research examines customer satisfaction with MFS. However, this research does not explain why MFS is expanding relatively more slowly than Internet financial services in general. Therefore, this study investigates this issue by determining the key drivers of MFS usage intention.	Absorptive capacity; Connectivity; Mobile financial services; Personal innovativeness; Structural equation modelling; Task-technology fit; Technology acceptance model	Perceived usefulness and perceived ease of use both serve as mediators between the first four of these five factors (task-fit, monetary value, connectivity, personal innovativeness, and absorptive capacity) and usage intention. Connectivity influences perceived ease-of-use directly. In addition, perceived monetary value has a significant effect on perceived usefulness, inferring MFS is not only useful for a firm, but also is useful from a time and monetary value standpoint. Personal innovativeness significantly influences perceived ease-of-use, so innovative users can take advantage of MFS more frequently. Absorptive capacity also directly affects usage intention. Finally, perceived task technology, versus a task characteristic view, significantly influences perceived usefulness.
Li et al.	2012	Literature review	-	This paper aims to illustrate the ontology framework (adding new devices, workflows, and services) using a media control example to illustrate the ontology, discovery, composition, deployment, execution, monitoring, and recovery.	Code generation; Composition; Ontology; Service-oriented; Smart home	This paper presented a novel framework for service-oriented smart home using ontology systems and used the semantic information in the ontology for discovery, composition, deployment, automated code generation, deployment, execution, and fault recovery.
Liew et al.	2017	Survey	204	The aim of this research is to examine factors influencing consumer acceptance of Internet of Things Technology (IoT) guiding by the Technology Acceptance Model (TAM)	Internet of Things; behavioural intention; Technology Acceptance Model, user perspective; perceived usefulness;	The Results revealed that the dimension of perceived usefulness is the most influencing factor on the consumers' acceptance of IoT technology and consumers' behavioural intention to use.
Lin	2011	Survey	559	Using innovation diffusion theory and knowledge-based trust literature, this study develops a research model to examine the effect of innovation attributes (perceived relative advantage, ease of use and compatibility) and knowledge-based trust (perceived competence, benevolence and integrity) on attitude and behavioural intention about adopting (or continuing to use) mobile banking across potential and repeat customers.	Attitude; Behavioural intention; Innovation diffusion; Knowledge-based trust; Mobile banking	The results indicate that perceived relative advantage, ease of use, compatibility, competence and integrity significantly influence attitude, which in turn lead to behavioural intention to adopt (or continue-to-use) mobile banking. Additionally, by using multi-group analysis with t-statistics, the results found that the antecedents of attitude

						toward mobile banking differ between potential and repeat customers.
Lu et al.	2018	Literature Review	-	In this paper we systematically review the business literature related to the Internet of Things and provide a critical account of the latest state of play. More specifically, we adopt two perspectives: that of the user and that of the organisation.	Internet of Things; systematic literature review; business perspective; users; organisations	In studies considering users in the context of the IoT, the most common foci are on customers' preferences of characteristics related to product design, users' acceptance and intention to purchase novel technologies, as well considerations of safety and privacy issues. From an organisational perspective, foci are on the issues of value creation, strategy, innovation, design and security.
Maddulety et al.	2017	Survey	302	This research examines the various factors which influence consumers purchase intention of smart appliances.	Smart appliances; smart home technologies; interoperability; Internet of Things	The research shows that all five factors have an impact on the purchase intention with interoperability having the strongest influence followed by privacy & control, technology, awareness and social factor.
Mani & Chouk	2017	Survey	402	The objective of this research is to develop a better understanding of the reasons underlying consumer resistance to smart and connected products.	Resistance; innovation; Internet of Things; smart and connected products; smartwatch	The findings show that perceived uselessness, perceived price, intrusiveness, perceived novelty and self-efficacy have an impact on consumer resistance to smart products. Moreover, privacy concerns have an effect on intrusiveness and dependence impacts privacy concerns.
Miorandi et al.	2012	Literature Review		In this survey article, we aim at providing a holistic perspective on the Internet-of-Things concept and development, including a critical revision of application fields, enabling technologies and research challenges.	Internet-of-Things; web smart objects; RFID; sensors actuators; interoperability security	A number of research challenges has been identified, which are expected to become major research trends in the next years. The most relevant application fields have been presented, and a number of use cases identified
Mital et al.	2016	Survey	314	Currently, there are still very few studies that explore the adoption of Internet of Things from a multiple theory perspective, namely, The Theory of Reasoned Action (TRA), The Theory of Planned Behaviour (TPB) and The Technology Acceptance Model (TAM). This research aims to satisfy a clear gap in the main field of research by proposing a Structured Equation Model (SEM) approach to test three competing models in the context of Internet of Things in India.	Internet of Things; healthcare; smart cities; smart supply-chain management; Indian market; multiple-theory based approach	The results of the study indicate that TAM, TPB and TRA explain the intention to use IOT equally well in terms of Goodness of Fit indicators i.e. SRMR and GF index but the impact perceived behavioural control was found to be non-significant.
Qasim & Abu-Shanab	2016	Empirical study		Despite the great potential of technology such as mobile payment in simplifying our lives, its uptake remains limited. As the technology acceptance fails to meet expectations, this study aims at providing a better understanding of the factors influencing mobile payment acceptance.	Empirical study; Jordan; Mobile payment; Network externalities; Technology acceptance; UTAUT	Results indicated that while the traditional acceptance drivers still impact customers' willingness to adopt mobile payment, network externalities was the most influential driver of mobile payment acceptance. Results also failed to support the influence of effort expectancy.
Rialle et al.	2002	Literature review		The aim of this article is to review the emerging concept of health “Smart” homes (HSH) and its potential through the	Smart Home; Health; Health Smart Home;	There is still no real trend towards a consensus in standardized concepts, definitions, or techniques. In the near future,

				use of telemedical information systems and communication technologies.		because of the real need for remote care systems, projects in this research area may have to be developed around specific requirements and key concepts unanimously adopted by representatives of every community involved in the remote care process.
Samaradiwakara & Gunawardena	2014	Literature review	-	This paper presents a part of an on-going research study which aims to develop a model on technology acceptance appropriate to the Sri Lankan context. Current paper reviews the theoretical literature to propose an improved theory/model from a comparison of existing technology acceptance theories/models.	Technology acceptance; Technology acceptance theories and models; Technology acceptance model comparison	Despite of the negative aspects identified in the theoretical paradigms of these theories/models, one significant paradigm out of fourteen theories/models could be drawn from the conceptual review on theory/model comparison presented here. Among the fourteen theories reviewed, UTAUT seems to be an improved theory that could provide a useful tool to assess the likelihood of success for technology acceptance studies.
Shin et al.	2018	Survey	310 & 2113	A smart home is considered a primary service of the Internet of Things (IoT), and global leading companies are launching smart home services/products based on the IoT. However, the spread of smart homes has been slower than expected, and analysis of smart homes from a demand perspective is required. This study suggests implications for promoting the smart home market by analysing factors affecting adoption and diffusion of smart homes.	Consumer behaviour; multivariate probit model; network externality; smart home; technology acceptance model	The results of this study show that compatibility, perceived ease of use, and perceived usefulness have significant positive effects on purchase intention.
Taherdoost	2018	Literature review	-	A number of models and frameworks have been developed to explain user adoption of new models regarding user acceptance of technology has been provided. The existing review will emphasize literature that tries to technologies and these models introduce factors that can affect the user acceptance. In this paper, an overview of theories and models regarding user acceptance of technology has been provided.	Acceptance Model; Acceptance Theory; Adoption Model; Adoption Theory; User Acceptance; User Adoption	In this paper, the most popular and used theories and models of user technology acceptance were discussed. UTAUT, TAM, and DOI seem to be the most common approaches in the field of Information Management.
Ur Rehman et al.	2013	Survey	465	The current study extends the traditional TAM (technology acceptance model) by incorporating different variables to understand the adoption of electronic shopping.	Electronic Shopping; E-Attitude; E-Usefulness; E-Ease of Use; E-Enjoyment; E-Risk; E-Trust; E- Self Efficacy	E-Attitude, E-Enjoyment and E-Risk are found significant predictors of electronic shopping intentions. E-Usefulness and E-Ease of use directly while E-Self Efficacy and E-Trust indirectly affects the E-Attitude. All the variables are found significant and the final model captures 71% variations in the intentions of the customers towards electronic shopping
Wang et al.	2013	Literature review	-	This paper establishes a framework for an Environmental Internet of Things (EIoT) and describes key technologies, including Wireless Sensor Network (WSN), network techniques, Geographic Information System (GIS), WebGIS, and distributed database techniques.	urban environment; Environmental Internet of Things; framework; Wireless Sensor Network; information platform	The paper discusses the construction of the EIoT and shows how it provides real-time monitoring at the residential level of environmental factors such as water, soil, atmosphere, noise, and wind. The EIoT can also realize online environmental simulation

						and management and is currently being extended to the city, regional, and national levels. The EIoT can improve understanding of the urban environment and help to provide advanced technological solutions for increasingly serious environmental problems.
Weber	2015	Literature review	-	This article highlights the growing need for appropriate regulatory as well as technical action in order to bridge the gap between the automated surveillance by IoT devices and the rights of individuals who are often unaware of the potential privacy risk to which they are exposed.	Data minimization; Internet of things; Privacy challenges; Privacy enhancing technologies; Quality of data; Transparency	This paper comes to the conclusion that new legal approaches for the protection of privacy need to be developed.
Yang et al.	2017	Survey	216	The purpose of this paper is to develop a comprehensive research model that can explain potential customers' behavioural intentions to adopt and use smart home services.	Interoperability; mobility; theory of planned behaviour; automation; security/privacy risk; smart home services	Mobility, security/privacy risk, and trust in the service provider are important factors affecting the adoption of smart home services.
Yousafzai et al.	2010	Survey	441	This paper uses structural equation modelling to ascertain the extent to which 3 popular models of users' behaviour—theory of reasoned action (TRA), theory of planned behaviour (TPB), and technology acceptance model (TAM)—are predictive of consumers' behaviour in the context of Internet banking.	Internet banking; behaviour; TAM; TRA; TPB; structural equation modelling	The results indicate that TAM is superior to the other models and highlights the importance of trust in understanding Internet banking behaviour.

Appendix 3: Questionnaire (German)

Herzlich Willkommen!

Vielen Dank, dass Sie an dieser Umfrage teilnehmen.

Mit Ihrer Teilnahme unterstützen Sie mich bei meiner Masterarbeit, die sich mit dem Thema Akzeptanz von Internet of Things (IoT) Technologie in Deutschland befasst.

Die Beantwortung des Fragebogens dauert **ca. 8 Minuten**. Alle Antworten sind anonym und werden streng vertraulich behandelt. Die Daten werden weder weitergegeben noch außerhalb dieses Projekts verwendet. Mit Abschluss meiner Masterarbeit werden alle gesammelten Daten gelöscht.

Die Umfrage beginnt zunächst mit einer Definition und Anwendungsbeispielen von IoT Technologie. Bitte nehmen Sie sich Zeit und lesen diesen Text aufmerksam durch. Im Anschluss werden mehrere Fragen gestellt. Auch hier bitte ich Sie die Fragen und Antworten genau durchzulesen, da einige Aussagen sich ähnlich anhören können. Beantworten Sie diese Fragen so gut Sie können.

Drücken Sie auf 'Nächste' um mit der Umfrage zu beginnen.

Was ist das Internet of Things?

Das Internet of Things (IoT), in Deutschland auch unter dem Namen 'Internet der Dinge' bekannt, bezeichnet die Vernetzung von Gegenständen mit dem Internet, damit diese Gegenstände selbstständig über das Internet kommunizieren und so verschiedene Aufgaben für den Besitzer erledigen können. Der Anwendungsbereich erstreckt sich dabei von einer allg. Informationsversorgung über automatische Bestellungen bis hin zu Warn- und Notfallfunktionen. (Gabler Wirtschaftslexikon)

Anwendungsbeispiele im Alltag

Ein großes Anwendungsfeld von IoT Technologie ist das **Smart Home**. Kameras, Sensoren an Fenstern oder Bewegungsmelder sorgen für Sicherheit, indem sie das Grundstück überwachen und über unbefugtes Eindringen informieren. Innerhalb des Hauses können Temperatur, Unterhaltungssysteme oder auch Haushaltsgeräte durch Nutzer per Smartphone oder Sprachansagen (Alexa, Siri, etc.) kontrolliert werden. Die Geräte passen sich dabei an die individuellen Gegebenheiten an und es wird bspw. der Energieverbrauch beim Verlassen des Hauses automatisch reguliert.

Des Weiteren wird IoT Technologie in der **Gesundheitsfürsorge** eingesetzt. Smartwatches und andere tragbare Geräte messen nicht nur Fitnesswerte wie gegangene Schritte, Blutdruck oder Pulsschlag, sondern machen auch auf Unregelmäßigkeiten aufmerksam und können im Ernstfall nach Hilfe rufen.

Darüber hinaus kann IoT Technologie auch beim **Aufspüren und Verfolgen** von wichtigen Gegenständen helfen. Ein Tracker am Schlüsselbund schickt bspw. eine Nachricht, wenn er zu weit vom Besitzer entfernt ist. Ebenso kann ein Tracker am Halsband eines Tieres Auskunft über die aktuelle Position geben.

1. Inwieweit stimmen Sie mit der folgenden Aussage überein?

"Ich kenne mich mit dem Thema IoT aus."

(1) ❑ trifft nicht zu
(2) ❑ trifft eher nicht zu
(3) ❑ teils-teils
(4) ❑ trifft eher zu
(5) ❑ trifft zu

2. Welche der folgenden IoT Technologien nutzen Sie? Mehrfachauswahl möglich.

(1) ❑ Digitales Sicherheitssystem
(2) ❑ Digitale Lichtkontrolle (z. B. Philips Hue)
(3) ❑ Smarter Lautsprecher (z. B. Amazon Echo)

(4) ❑ Smartwatch (z. B. Apple Watch)
(5) ❑ Smart TV
(6) ❑ Smartes Haushaltsgerät
(7) ❑ Smartes Energiemanagement (z. B. smartes Thermostat)
(8) ❑ Keine
(9) ❑ Andere _____

Während des folgenden Abschnitts erscheinen verschiedene Aussagen zum Thema IoT, die auf einer fünfstelligen Skala von 'trifft nicht zu' bis 'trifft zu' beantwortet werden sollen.
Einige der Aussagen können sich ähnlich anhören. Deswegen ist es wichtig, dass Sie sich die Aussagen genau durchlesen und nach bestem Gewissen beantworten. Wählen Sie die Antworten basierend auf dem gerade gelesenen Text sowie Ihren Vorkenntnissen aus.

Drücken Sie auf 'Nächste' um mit der Umfrage fortzufahren.

3. Inwieweit stimmen Sie mit den folgenden Aussagen überein?

	(1) trifft nicht zu	(2) trifft eher nicht zu	(3) teils-teils	(4) trifft eher zu	(5) trifft zu
IoT Technologie wird nützlich in meinem Alltag sein.	❑	❑	❑	❑	❑
Ich kann IoT Technologie bedienen.	❑	❑	❑	❑	❑
IoT Technologie ist vertrauenswürdig.	❑	❑	❑	❑	❑
Ich erwarte IoT Technologie in naher Zukunft zu nutzen.	❑	❑	❑	❑	❑
IoT Technologie ermöglicht es mir Aufgaben im Alltag mit weniger Aufwand zu erledigen.	❑	❑	❑	❑	❑

4. Inwieweit stimmen Sie mit den folgenden Aussagen überein?

	(1) trifft nicht zu	(2) trifft eher nicht zu	(3) teils-teils	(4) trifft eher zu	(5) trifft zu
IoT Technologie erleichtert das Erledigen von Aufgaben im Alltag.	❑	❑	❑	❑	❑
IoT Technologie erfordert viel geistige Anstrengung.	❑	❑	❑	❑	❑
Anbieter von IoT Technologie halten ihre Versprechen und Zusagen.	❑	❑	❑	❑	❑
Es ist komfortabel IoT Technologie zu nutzen.	❑	❑	❑	❑	❑

5. Inwieweit stimmen Sie mit den folgenden Aussagen überein?

	(1) trifft nicht zu	(2) trifft eher nicht zu	(3) teils-teils	(4) trifft eher zu	(5) trifft zu
IoT Technologie sorgt dafür, dass ich leistungsfähiger im Alltag bin.	❑	❑	❑	❑	❑
Die Nutzung von IoT Technologie ist verständlich.	❑	❑	❑	❑	❑
Anbieter von IoT Technologie haben auch meine Interessen im Sinn.	❑	❑	❑	❑	❑
Ich beabsichtige IoT Technologie zu nutzen.	❑	❑	❑	❑	❑

6. Inwieweit stimmen Sie mit den folgenden Aussagen überein?

	(1) trifft nicht zu	(2) trifft eher nicht zu	(3) teils-teils	(4) trifft eher zu	(5) trifft zu
Durch IoT Technologie kann ich Aufgaben im Alltag schneller erledigen.	❑	❑	❑	❑	❑

Die Nutzung von IoT Technologie ist einfach.	❑	❑	❑	❑	❑
IoT Technologie bietet zuverlässige Informationen.	❑	❑	❑	❑	❑
Ich bin entschlossen bald IoT Technologien zu nutzen.	❑	❑	❑	❑	❑

7. Inwieweit stimmen Sie mit den folgenden Aussagen überein?

	(1) trifft nicht zu	(2) trifft eher nicht zu	(3) teils-teils	(4) trifft eher zu	(5) trifft zu
Die Entscheidung IoT Technologie zu nutzen ist abhängig von Anregungen meiner Freunde.	❑	❑	❑	❑	❑
Die Entscheidung IoT Technologie zu nutzen ist abhängig von Anregungen der Medien.	❑	❑	❑	❑	❑
Die Entscheidung IoT Technologie zu nutzen ist abhängig von Anregungen meiner Familie.	❑	❑	❑	❑	❑

Im Anschluss gibt es nun noch einige Fragen zu Ihrer Person.

8. In welchem Land leben Sie?

(Dropdown)

9. Welche Nationalität haben Sie?

(Dropdown)

10. Welches Geschlecht haben Sie?

(1) ❑ Männlich

(2) ❑ Weiblich

(3) ❑ Divers

11. Wie alt sind Sie?

___

12. Welcher ist Ihr höchster Bildungsabschluss?

(1) ❑ Kein Schulabschluss
(2) ❑ Hauptschulabschluss
(3) ❑ Realschulabschluss (Mittlere Reife)
(4) ❑ Gymnasialabschluss (Abitur)
(5) ❑ Abgeschlossene Ausbildung
(6) ❑ Universitätsabschluss (Bachelor)
(7) ❑ Universitätsabschluss (Master)
(8) ❑ Promotion
(9) ❑ Habilitation
(10) ❑ Anderer _____

Vielen Dank für die Teilnahme an der Umfrage und die Beantwortung aller Fragen.

Durch Ihre Unterstützung haben Sie mir sehr bei meiner Thesis geholfen.

Mit einem Klick auf 'Fertig stellen' beenden Sie die Umfrage.

Appendix 4: Questionnaire (English)

Welcome!

Thank you very much for participating in this survey!

With your participation, you support my master thesis about the adoption of Internet of Things (IoT) technology in Germany.

Answering the questionnaire will take **approx. 8 minutes**. All answers are anonymous and will be treated strictly confidential. The collected data will be deleted once the master thesis is finished.

The survey begins with a definition and examples of application of IoT technology. Please take your time to read this text thoroughly. Following, several questions will be asked. Again, please read the statements and answers thoroughly because some statements can sound alike. Answer these questions as good as you can.

Click ‘Next’ to start the survey.

What is the Internet of Things?

The Internet of Things (IoT), also known as Internet der Dinge in Germany, is the interconnectedness of objects with the Internet and the autonomous communication of these objects in order to execute diverse tasks for the owner. The field of application ranges from simple supply of information to automatically ordering as well as alarming and emergency functions.

Fields of application in everyday life

A huge field of application of IoT technology is the **Smart Home**. Cameras, windows with sensors, or motion detectors ensure safety by monitoring the property and informing about unauthorized entries. Within the household, it is possible to control

the temperature, entertainment systems, or appliances through a touch on the smartphone or voice commands (Alexa, Siri, etc.). The devices customize according to the individual circumstances which, for instance, automatically regulates the energy consumption when leaving the house.

Furthermore, IoT technology is used in the **health care**. Smartwatches and other wearable devices do not only measure taken steps, blood pressure, or the heart rate, but they also alert users when there are irregularities and can call for help in case of emergency.

In addition, IoT technology can also help to **detect and track** important items. For instance, a tracker on a keychain can send a message when its left behind. Likewise, a tracker on a collar can inform about the current position of the pet.

1. Inwieweit stimmen Sie mit der folgenden Aussage überein?

"Ich kenne mich mit dem Thema IoT aus."

(1) ❑ disagree
(2) ❑ rather disagree
(3) ❑ partly
(4) ❑ rather agree
(5) ❑ agree

2. Which of the following IoT technologies do you use? Multiple selection possible.

(1) ❑ Digital security system
(2) ❑ Digital light control (e.g. Philips Hue)
(3) ❑ Smart speaker (e.g. Amazon Echo)
(4) ❑ Smartwatch (e.g. Apple Watch)
(5) ❑ Smart TV
(6) ❑ Smart appliance

(7) ❑ Smart energy management (e.g. smart thermostat)

(8) ❑ None

(9) ❑ Other _____

During the following section you will be presented with different statements about the topic of IoT which should be answered on a five-point scale from ‘disagree’ to ‘agree’.

Some of the statements can sound similar. This is why it is important to read the statements very thoroughly and respond to the best of your knowledge.

Select the answers based on the previously read text as well as your previous knowledge.

Click ‘Next’ to continue with the survey.

3. To what extent do you agree with the following statements?

	(1) disagree	(2) rather disagree	(3) partily	(4) rather agree	(5) agree
IoT technology will be useful in my daily life.	❑	❑	❑	❑	❑
I am able to operate IoT technology.	❑	❑	❑	❑	❑
IoT technology is trustworthy.	❑	❑	❑	❑	❑
I expect to use IoT technology in the near future.	❑	❑	❑	❑	❑
Using IoT technology will reduce the effort required in accomplishing my daily activities.	❑	❑	❑	❑	❑

4. To what extent do you agree with the following statements?

	(1) disagree	(2) rather disagree	(3) partily	(4) rather agree	(5) agree
IoT technology will make it easier for me to do my daily activities.	❑	❑	❑	❑	❑
IoT technology requires a lot of mental effort.	❑	❑	❑	❑	❑
IoT technology providers keep their promises and commitments.	❑	❑	❑	❑	❑
I expect to use IoT technology in the near future.	❑	❑	❑	❑	❑
Accessing IoT technology is convenient.	❑	❑	❑	❑	❑

5. To what extent do you agree with the following statements?

	(1) disagree	(2) rather disagree	(3) partily	(4) rather agree	(5) agree
IoT technology will improve my performance of daily activities.	❑	❑	❑	❑	❑
IoT technology is clear to use.	❑	❑	❑	❑	❑
IoT technology provider keep my best interests in mind.	❑	❑	❑	❑	❑
I intend to use IoT technology.	❑	❑	❑	❑	❑

6. To what extent do you agree with the following statements?

	(1) disagree	(2) rather disagree	(3) partily	(4) rather agree	(5) agree
IoT technology will make me accomplish my daily activities more quickly.	❑	❑	❑	❑	❑
IoT technology is easy to use.	❑	❑	❑	❑	❑

IoT technology provides reliable information.	❑	❑	❑	❑	❑
Ich bin entschlossen bald IoT Technologien zu nutzen.	❑	❑	❑	❑	❑

7. To what extent do you agree with the following statements?

	(1) disagree	(2) rather disagree	(3) partily	(4) rather agree	(5) agree
The decision to use IoT technology is because my friends encourage the use of IoT technology.	❑	❑	❑	❑	❑
The decision to use IoT technology is because the media encourage the use of IoT technology.	❑	❑	❑	❑	❑
The decision to use IoT technology is because my family encourage the use of IoT technology.	❑	❑	❑	❑	❑

In the following, there will be some questions about your person.

8. In which country do you live?

(Dropdown)

9. Which nationality do you have?

(Dropdown)

10. What is your gender?

(1) ❑ Male
(2) ❑ Female
(3) ❑ Diverse

11. How old are you?

___

12. What is your highest level of education?

(1) ❑ No graduation
(2) ❑ Hauptschulabschluss
(3) ❑ Secondary School certificate (Mittlere Reife)
(4) ❑ Gymnasialabschluss (Abitur)
(5) ❑ Completed apprenticeship
(6) ❑ University degree (Bachelor)
(7) ❑ University degree (Master)
(8) ❑ Promotion
(9) ❑ Habilitation
(10) ❑ Other _____

Thank you very much for participating in this survey and the answering of all questions.

You helped me very much with my thesis by supporting me with your participation.

The survey ends with a click on ‘Finish’.

Appendix 5: SPSS Output (Multiple Regression Analysis)

Correlations

		Adoption	PU	PEOU	Trust	Social
Pearson Correlation	Adoption	1.000	.490	.385	.672	.524
	PU	.490	1.000	.168	.468	.204
	PEOU	.385	.168	1.000	.364	.353
	Trust	.672	.468	.364	1.000	.627
	Social	.524	.204	.353	.627	1.000
Sig. (1-tailed)	Adoption	.	.000	.000	.000	.000
	PU	.000	.	.017	.000	.005
	PEOU	.000	.017	.	.000	.000
	Trust	.000	.000	.000	.	.000
	Social	.000	.005	.000	.000	.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.532	.520	.28348

a. Predictors: (Constant), Social, PU, PEOU, Trust

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.982	4	3.495	43.497	.000[b]
	Residual	12.295	153	.080		
	Total	26.276	157			

a. Dependent Variable: Adoption

b. Predictors: (Constant), Social, PU, PEOU, Trust

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-1.521	.559		-2.724	.007		
	PU	.428	.110	.246	3.897	.000	.768	1.303
	PEOU	.301	.133	.137	2.273	.024	.842	1.188
	Trust	.394	.080	.395	4.912	.000	.473	2.115
	Social	.179	.073	.178	2.451	.015	.579	1.727

a. Dependent Variable: Adoption

Appendix 6: SPSS Output (Linear Regression Analysis)

Correlations

		PU	PEOU
Pearson Correlation	PU	1.000	.168
	PEOU	.168	1.000
Sig. (1-tailed)	PU	.	.017
	PEOU	.017	.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.168[a]	.028	.022	.23252

a. Predictors: (Constant), PEOU

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.246	1	.246	4.541	.035[b]
	Residual	8.434	156	.054		
	Total	8.680	157			

a. Dependent Variable: PU

b. Predictors: (Constant), PEOU

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.996	.377		7.946	.000
	PEOU	.212	.100	.168	2.131	.035

a. Dependent Variable: PU