Mobile Information Systems' Security, Privacy, and Environmental Sustainability Aspects

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To my beloved parents,

my lovely wife Tuba,

and my beautiful daughter Melis.

I. Abstract

Mobile information systems (IS) such as smartphones and tablets have become an integral part of individuals' daily lives and are creating new possibilities due to continuous advances in sensor technologies. This doctoral thesis aims to contribute to the field of mobile IS research by exploring three various aspects: information security, information privacy, and environmental sustainability. Considering security aspects of mobile IS, a trend called "bring your own device" (BYOD) is analyzed. BYOD enables employees to use personal mobile devices for working purposes. However, it also endangers organizations concerning corporate data to be exposed to diverse security threats such as the possibility of corporate data loss and theft. In this thesis, the focus is to examine the influence of cultural differences of BYOD. With regard to privacy aspects of mobile IS, the disclosure of personal information through mobile applications (apps) is investigated. Upon installation, mobile apps gain access to users' personal information regarding their identity, location, and other sensitive data like contact lists, photos and videos, as well as text messages. The objective of the thesis is to analyze the effect of mobile apps' access to personal information on mobile users' privacy concerns. Referring to environmental sustainability aspects, the role of mobile IS in the face of ongoing global warming is examined. The focus is on electric vehicles (EVs), which are regarded as a promising transportation alternative to reduce greenhouse gas (GHG) emissions substantially. In this thesis, the impact of smartphone-based driver assistance systems on the energy consumption of EVs is investigated.

Keywords: Mobile Information Systems, Information Security, Information Privacy, Environmental Sustainability, Electric Vehicles, Mobile Applications, Bring Your Own Device

Mobile Informationssysteme (IS) wie Smartphones und Tablets sind zu einem wesentlichen Bestandteil des Alltags geworden und schaffen neue Möglichkeiten aufgrund kontinuierlicher Fortschritte in der Sensortechnologie. Ziel dieser Dissertation ist es, einen Beitrag zur mobilen IS-Forschung zu leisten, indem drei unterschiedliche Aspekte untersucht werden: Informationssicherheit, Informationsprivatheit und ökologische Nachhaltigkeit. In Bezug auf Sicherheitsaspekte mobiler Systeme, wird ein Trend namens „Bring Your Own Device" (BYOD) analysiert. BYOD ermöglicht Mitarbeitern, persönliche, mobile Endgeräte für Arbeitszwecke zu nutzen. Allerdings werden hierdurch Organisationen gefährdet, die verschiedenen Sicherheitsrisiken wie etwa den möglichen Verlust oder Diebstahl von Unternehmensdaten ausgesetzt sind. In dieser Dissertation liegt der Fokus auf der Untersuchung des Einflusses von kulturellen Differenzen von BYOD. Im Hinblick auf Aspekte der Informationsprivatheit, wird die Offenlegung von persönlichen Informationen durch mobile Applikationen (Apps) erforscht. Bei der Installation erhalten mobile Apps Zugriff auf persönliche Informationen der Nutzer hinsichtlich der Identität, des Standortes und anderer sensibler Daten wie Kontaktlisten, Fotos und Videos sowie Textnachrichten. Die Dissertation zielt darauf ab, Privatsphärebedenken mobiler Nutzer zu analysieren, welche durch den Zugriff von mobilen Apps auf persönliche Informationen ausgelöst werden. Bezugnehmend auf Aspekte der ökologischen Nachhaltigkeit, wird die Rolle mobiler Systeme angesichts der zunehmenden globalen Erwärmung untersucht. Der Fokus liegt hierbei auf Elektrofahrzeugen, welche als eine vielversprechende Alternative im Transportwesen betrachtet werden, um Treibhausgasemissionen erheblich zu reduzieren. In dieser Dissertation wird die Auswirkung von Smartphone-basierten Fahrerassistenzsystemen auf den Energieverbrauch von Elektrofahrzeugen erforscht.

Schlagwörter: Mobile Informationssysteme, Informationssicherheit, Informationsprivatheit, ökologische Nachhaltigkeit, Elektrofahrzeuge, mobile Applikationen, Bring Your Own Device

II. Management Summary

Anytime and anywhere accessibility is a key part of the success of mobile information systems (IS) such as smartphones and tablets. New opportunities are possible through advances in sensor technologies like built-in cameras, proximity sensors, accelerometers, gyroscopes, and Global Positioning System (GPS) receivers. According to a KPCB internet trends report, as of the year 2014, there are 5.2 billion mobile users globally, of which 40 percent are smartphone users (Meeker 2015). Apart from the benefits of mobile IS, there are also several drawbacks, for example, distinct aspects of security and privacy threats. In this doctoral thesis, these two drawback aspects of mobile IS are explored with a focus on a trend called “bring your own device” (BYOD) and the case of permission requests of mobile applications (apps). A third aspect of the thesis refers to the role of mobile IS as an integral part of IS for environmental sustainability with a focus on the energy-efficiency of electric vehicles (EVs).

The thesis investigates the following three aspects. First, the trend of BYOD is analyzed. In information technology (IT) consumerization, BYOD refers to employees using their personal mobile devices to access corporate data anywhere, anytime, and with various mobile devices. Advantages include the freedom to choose any device, an easier technology adoption, and an increased workforce availability when business needs occur. Disadvantages entail security threats, privacy concerns, and legal problems as well as increased workload for employees. Since BYOD is voluntary for employees, organizations that wish to successfully implement BYOD need to understand employees’ behavior, which is mainly predicted from employees’ intention to use their personal mobile devices for work purposes. Due to the versatile and international scope of BYOD, this thesis analyzes cultural differences of BYOD. According to Hofstede et al. (2010), six cultural dimensions are compared to investigate cultural differences: power distance, individualism, masculinity, uncertainty avoidance,

long-term orientation, and indulgence. Culture scores allow to compare different cultures regarding the six cultural dimensions (see Figure I). Mature countries leading the IT sector are selected: the United States as a representative country for the Anglo-American culture, Germany on behalf of the Central European culture, and South Korea representing the Asian culture.

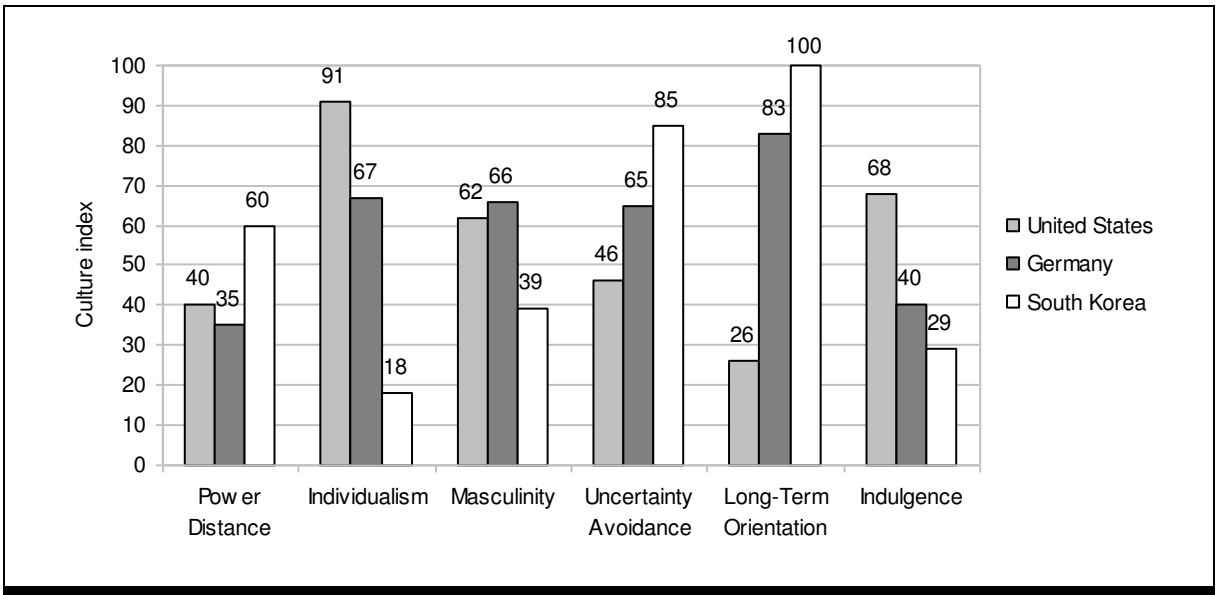

Figure I. Cultural Dimensions for the United States, Germany, and South Korea

The employees' intention to use is measured using the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989). The results of a survey of 542 employees from three different cultures show that cultural differences among American, German, and Korean employees significantly affect the intention of bringing their own devices to work. The most significant difference occurs for the construct of perceived uncertainty toward BYOD. American employees place the highest importance on perceived uncertainty, followed by German employees, with no significant impact for Korean employees (see Figure II). It is concluded that this large difference is due to the fact that individualist cultures, like the United States and Germany, pursue individual interests and therefore are more concerned about security, privacy, and legal issues that could harm the individual self. In comparison, collectivist cultures like South Korea place more importance on collective interests such as the organization's interest to implement

BYOD above individual interests regarding the liability of loss of corporate data, possible disclosure of personal information, or risk of legal issues.

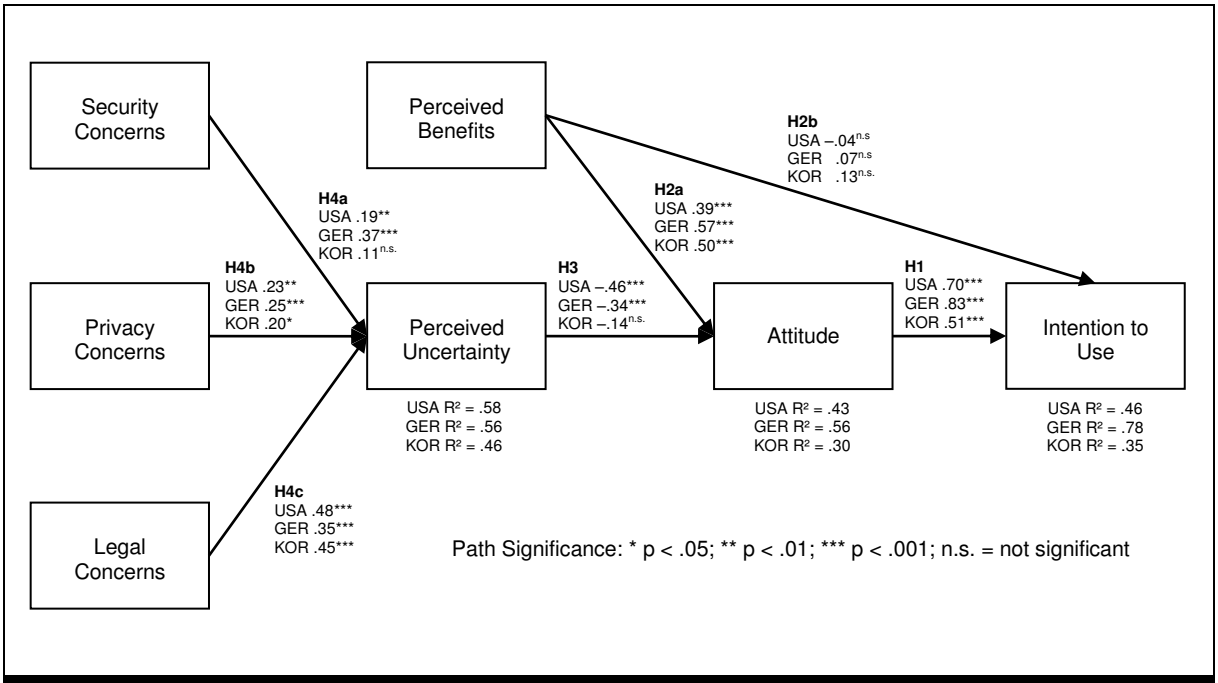

Figure II. Results of Structural Equation Modeling

Second, permission requests of mobile apps are examined. Mobile apps have become highly popular and are creating new economic opportunities for app providers, developers, software companies, and advertisers. Due to the access to personal information, mobile apps may pose a threat to users' privacy, which can incite users not to install or to uninstall mobile apps. In the last twenty years, concerns for information privacy (CFIP) have been investigated by several studies, which adapted CFIP to an online and to a mobile context. In this thesis, an extended approach for mobile users' information privacy concerns (MUIPC) analyzes four dimensions of access to personal information, i.e., personal identity, location, device content, and system and network settings. In order to measure access to personal information as an antecedent to MUIPC, permission requests of several mobile apps are systematically reviewed and analyzed. Results of the app review allow for a categorization of permission requests (see Table I).

Table I. List of Common Mobile Application Permissions	
Categories	**Permissions**
Phone calls	Read phone status and identity
Microphone	Record audio
Your location	Approximate location (network-based)
	Precise location (GPS and network-based)
Your social information	Read your contacts
Storage	Modify or delete the contents of your USB storage
Your accounts	Add or remove accounts
	Find accounts on the device
	Use accounts on the device
Network communication	Full network access
	Receive data from Internet
	View network connections
	View Wi-Fi connections
Affects Battery	Control vibration
	Prevent phone from sleeping
Sync settings	Read sync settings
System tools	Test access to protected storage

The influence of access to personal information on MUIPC is tested with a structural equation model (SEM) by conducting a survey of 474 mobile app users. The results indicate that access to personal identity, location, and device content are significantly positive in relation to MUIPC. Access to system and network settings is not found to be significant (see Figure III). Upon these results, app providers should recognize access to personal identity, location, and device content as a significant indicator affecting MUIPC. Understanding mobile users' privacy concerns allows app providers to better address drawbacks resulting from those concerns. App providers should ensure that they access personal information stored on mobile devices only if necessary and justified with value-added services. For example, location should only be tracked if the mobile app requires this function to work properly, such as with the navigation system of the Google Maps mobile app.

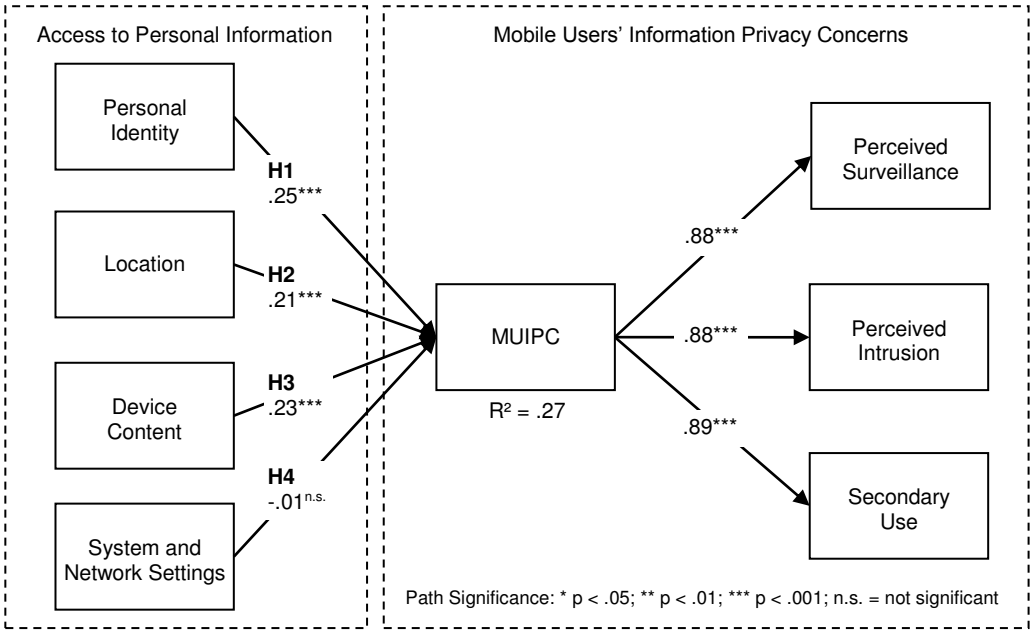

Figure III. Results of Structural Equation Modeling

Third, energy reduction of EVs through mobile apps is investigated. The role of IS for environmental sustainability has received considerable attention over the last several years. In view of global warming and climate change, a transition from combustion to EVs can help reduce greenhouse gas (GHG) emissions. Since sustainable behavior often lacks relevant information about its environmental effects, the role of IS in influencing energy consumption is being explored in this thesis. The main focus is to investigate the impact of driver assistance systems in the form of mobile apps on the energy consumption of EVs. To test such an impact, a field experiment is conducted by defining a control group and an experimental group. Test drives are performed with an all-electric, lithium-ion battery powered, small passenger city car. As the treatment of the study, a mobile app called "Smooth Driver" is chosen that monitors excessive acceleration and hard braking. The research study follows the presumption that IS provides information about the environmental impact of personal decisions (Watson et al. 2012) and it is thus assumed that smartphone-based driver assistance systems will significantly influence driving behavior and consequently reduce energy consumption (see Figure IV).

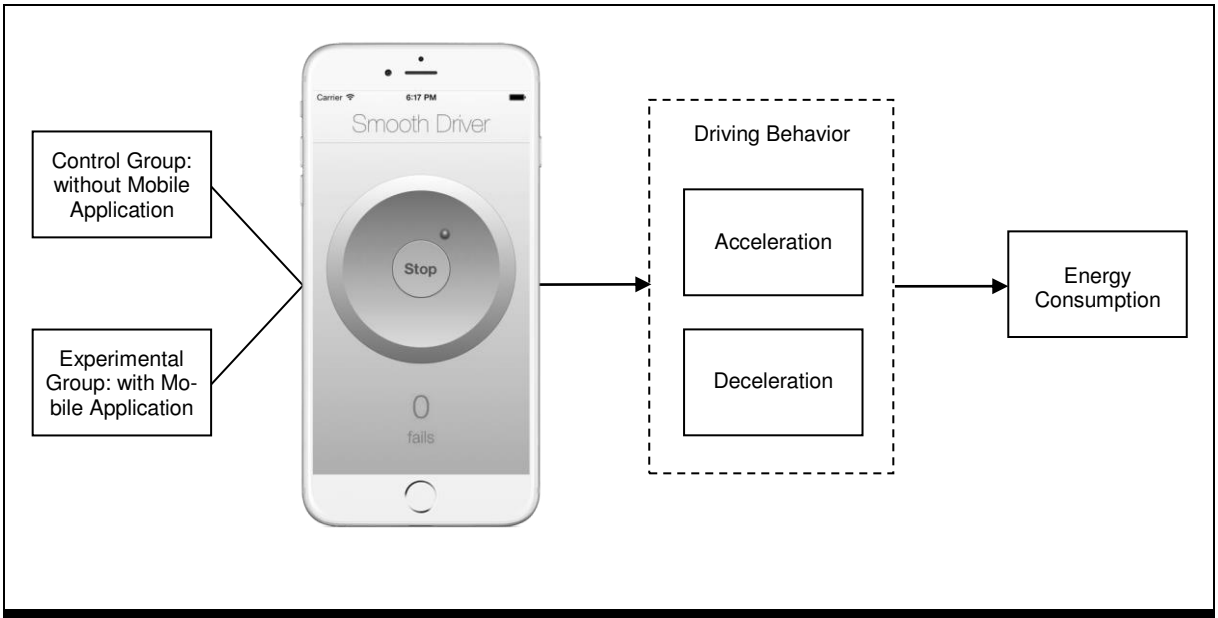

Figure IV. Experimental Setting

The results reveal significant differences among the control group and the experimental group, which indicate that using smartphone-based driver assistance systems significantly reduces the energy consumption of EVs. Through the deployment of the mobile app, the average energy consumption decreases from 12.6 kWh/100 km to 11.4 kWh/100 km, which implies an energy reduction by 9.5 percent (see Figure V). This entails several benefits, including an increase of range of EVs, electricity cost savings, decrease of vehicle wear through energy-efficient driving, and reduction of GHG emissions. The subjects of the test drives who drove the test route with the mobile app consumed less energy and required only a little more time. This comparison shows that energy-efficient driving does not necessarily involve a delay in the time of arrival. Mobile apps that monitor excessive acceleration and hard braking can help to drive more energy-efficiently. Considering the competition among automotive manufacturers to lower operating costs and lower CO_2 emissions, automotive manufacturers should consider to provide driver assistance systems (smartphone-based or on-board) to their customers that allow to control energy consumption.

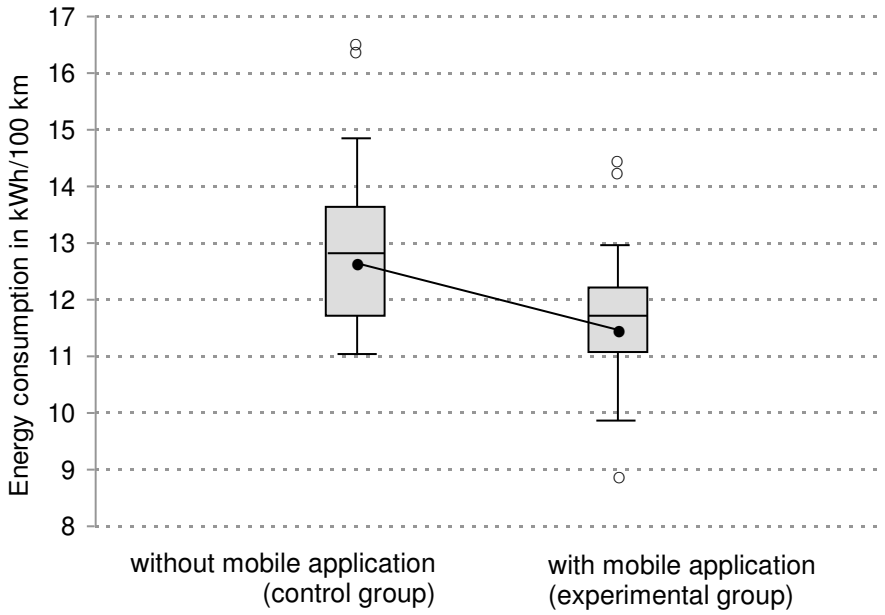

Figure V. Boxplot for the Results of the Experiment

This thesis has the overall aim to contribute to mobile IS research by exploring three various aspects in the field of information security, information privacy, and environmental sustainability. For this reason, the research studies in focus in this thesis have been developed, conducted, and presented at leading IS conferences all over the world (the United States, Italy, and Germany), where the papers have been double-blind peer-reviewed and accepted for publication in the conference proceedings. The quality of one research paper has been honored with a “Best Conference Paper” award from the Association for Information Systems (AIS), which is “the premier professional association for individuals and organizations who lead the research, teaching, practice, and study of information systems worldwide”[1]. From a practical perspective, findings of the thesis provide recommendations for practitioners in the context of implementing BYOD in organizations and companies, understanding mobile users’ privacy concerns in terms of permissions requests of mobile apps, and improving the energy-efficiency of EVs by deploying driver assistance systems.

[1] https://aisnet.org/page/AboutAIS

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VI. List of Abbreviations

ACM	Association for Computing Machinery
AG	Aktiengesellschaft
AIS	Association for Information Systems
AISeL	AIS Electronic Library
AMCIS	Americas Conference on Information Systems
AVE	Average Variance Extracted
BAO	Belief-Action-Outcome
BISE	Business & Information Systems Engineering
BYOD	Bring Your Own Device
CAIS	Communications of the Association for Information Systems
cf.	compare
CFIP	Concern for Information Privacy
CMS	Carbon Management System
CO_2	Carbon Dioxide
COPE	Corporate Owned Personally Enabled
CR	Composite Reliability
CYOD	Choose Your Own Device
df	degrees of freedom
e. g.	exempli gratia (for example)
e. V.	eingetragener Verein
ECIS	European Conference on Information Systems
EFA	Exploratory Factor Analysis
EJIS	European Journal of Information Systems
ERP Singapore	Electronic Road Pricing in Singapore
et al.	et alii (and others)
EV	Electric Vehicle
GER	Germany

GHG	Greenhouse Gas
GI-FB WI	Gesellschaft für Informatik – Fachbereich Wirtschaftsinformatik
GPS	Global Positioning System
H	Hypothesis
HICSS	Hawaii International Conference on System Sciences
i. e.	id est (that is)
IBSG	Internet Business Solutions Group
ICIS	International Conference on Information Systems
IDG	International Data Group
IDV	Individualism versus Collectivism
IEEE	Institute of Electrical and Electronics Engineers
IS	Information Systems
ISJ	Information Systems Journal
ISR	Information Systems Research
IT	Information Technology
IUIPC	Internet Users' Information Privacy Concerns
IVR	Indulgence versus Restraint
IWI	Institut für Wirtschaftsinformatik
JAIS	Journal of the Association for Information Systems
JIT	Journal of Information Technology
JMIS	Journal of Management Information Systems
JSIS	Journal of Strategic Information Systems
km	kilometer
KOR	Korea
kWh	kilowatt-hour
LBS	Location-Based Services
LTO	Long-Term Orientation versus Short-Term Orientation
MAS	Masculinity versus Femininity
MISQ	Management Information Systems Quarterly

MKWI	Multikonferenz Wirtschaftsinformatik
MUIPC	Mobile Users' Information Privacy Concerns
NFC	Near Field Communication
no.	number
OS	Operating System
p.	page
PACIS	Pacific Asia Conference on Information Systems
PC	Path Coefficient
PCA	Principal Component Analysis
PDI	Power Distance Index
RQ	Research Question
SE	Standard Error
SEM	Structural Equation Modeling
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
TRUSTe	True Ultimate Standards Everywhere
UAI	Uncertainty Avoidance Index
USA	United States of America
VHB	Verband der Hochschullehrer für Betriebswirtschaft
WI	Wirtschaftsinformatik
WKWI	Wissenschaftliche Kommission Wirtschaftsinformatik

VII. Overview of Publications

In an early stage of his doctoral studies at the Institute for Information Systems Research of the University of Hannover, the author began to investigate security and privacy aspects of mobile information systems with a focus on “bring your own device” (BYOD) and permission requests of mobile applications. Initially, the intention to use BYOD was examined by developing a research model based on the theory of reasoned action and technology acceptance model. A survey with German employees was conducted and collected data was empirically analyzed using structural equation modeling. The research article entitled “Investigating the Influence of Security, Privacy, and Legal Concerns on Employees’ Intention to Use BYOD Mobile Devices” (see Appendix 1) was presented by the author at the Americas Conference on Information Systems (AMCIS) in Chicago, Illinois, USA in 2013 and was published in the conference proceedings.[2] The Association for Information Systems honored the work with a “Best Conference Paper” award. At a later time, the research on BYOD was expanded by adding the United States and South Korea as new cultures of focus to Germany in order to analyze cultural differences of BYOD. This significantly modified version of the paper entitled “Bring Your Own Device: Cultural Differences of Employees’ Intention to Use Personal Mobile Devices for Work” (see Appendix 2) was submitted to the Management Information Systems Quarterly (MISQ), which is often ranked the number one journal in the field of information systems. The author continued his research in the field of information security and privacy by conducting a research study about permission requests of mobile applications. This study entitled “Mobile Applications and Access to Personal Information: A Discussion of Users’ Privacy Concerns” (see Appendix 3) was presented by the author at the International Conference on Information Systems (ICIS) in Milan, Italy in 2013 and was published

[2] http://aisel.aisnet.org/amcis2013/ISSecurity/GeneralPresentations/8/

in the conference proceedings.[3] ICIS is considered as the leading conference in information systems research.

What followed was a project entitled “Showcase Electric Mobility”, funded by the German Federal Ministry for Economic Affairs and Energy under grant no. 16SNI011B. The project was a cooperation between industry partner Volkswagen AG and university partners Braunschweig University of Technology, University of Hannover, Ostfalia University of Applied Sciences, and Clausthal University of Technology, as well as the Automotive Research Center Niedersachsen. The focus of the project was on Volkswagen’s carsharing service “Quicar”, which was available in Hannover, Germany. The project had the title “Quicar Electric” and was later renamed “Think Blue. e-Carsharing Volkswagen AG”. The author of this thesis developed several research studies within the frame of the project in the research areas of electric vehicles, carsharing, and electric carsharing.

With regard to the topic of electric vehicles, the author examined how the energy consumption of electric vehicles can be reduced by deploying driver assistance systems in the form of mobile applications. This study entitled “How Can Mobile Applications Reduce Energy Consumption? An Experimental Investigation of Electric Vehicles” (see Appendix 4) was presented by the author at the European Conference on Information Systems (ECIS) in Münster, Germany in 2015 and was published in the conference proceedings.[4] ECIS is considered as the premier information systems conference in the European and Middle East region. Another paper regarding electric vehicles refers to the market introduction of electric vehicles. In this paper, strengths, weaknesses, opportunities, and threats are analyzed with a focus on the market introduction of Volkswagen’s electric cars “e-up!” in 2013 and “e-Golf” in 2014. The paper entitled “Market Introduction of Electric Cars: A SWOT Analysis” (see Appendix

[3] http://aisel.aisnet.org/icis2013/proceedings/SecurityOfIS/6/
[4] http://aisel.aisnet.org/ecis2015_cr/36/

5) was published in the “IWI Discussion Paper Series”. The acceptance and diffusion of electric vehicles are explored in the paper “Elektromobilität in Deutschland und anderen Ländern: Vergleich von Akzeptanz und Verbreitung” (see Appendix 6), which was also published in the “IWI Discussion Paper Series”. The electric vehicles markets in Germany, the United States, Japan, and Norway are analyzed with the result that approximately 98 percent of electricity is produced from renewable energy sources in Norway, but only 12 to 30 percent in Japan, the United States, and Germany. Furthermore, a qualitative content analysis is developed by conducting a survey with 40 end user subjects. Results of the survey suggest that environmental sustainability is the main driver for acceptance of electric vehicles. Almost all of the subjects (39 out of 40) indicate that environmental sustainability has absolute priority when it comes to electric vehicles, and 18 subjects state that electricity for electric vehicles should be produced from renewable energy sources.

Considering research in the carsharing area, as an initial step, the author conducted a literature review identifying 93 articles published from 2003 to 2013. In this process, 6 key concepts are uncovered, i.e., market analysis, location, travel behavior, information systems, electric carsharing, and sustainability. Since the paper is addressed to the information systems community in the first place, implications of the literature review focus on the field of information systems research. The paper entitled “Carsharing: A Literature Review and a Perspective for Information Systems Research” (see Appendix 7) was presented by the author at the “Multikonferenz Wirtschaftsinformatik” (MKWI) in Paderborn, Germany in 2014 and was published in the conference proceedings. The author extended the literature review to 130 articles published from 1999 to 2014 and derived critical success factors for carsharing services. Findings show that carsharing services are successful particularly within areas involving the following characteristics: high population density, lower rates of car ownership, areas with limited and expensive parking, pedestrian and bike friendly areas, as well as locations with mixed-use developments. Further success factors

are shorter access distances to carsharing locations, cooperation with relevant stakeholders, incentives to members, and the implementation of information systems. The paper entitled “A Systematic Literature Review of Carsharing Research: Concepts and Critical Success Factors” (see Appendix 8) was published in the “IWI Discussion Paper Series”.

Referring to electric carsharing, sense of community and motivation of electric carsharing usage is investigated in the paper “Gemeinschaftsgefühl und Motivationshintergrund: Eine qualitative Inhaltsanalyse im Bereich des Elektro-Carsharing” (see Appendix 9). Results of a qualitative survey with 35 end user subjects show that the subjects exhibit an interest in environmental sustainability regarding electric carsharing in terms of sense of community and motivation. Some of the subjects are convinced of the concept of electric carsharing, however, some are sceptic (uncertainty toward charging as well as production and disposal of vehicles). Another paper regarding electric carsharing refers to the effect of experiencing electric vehicles. In this paper, which is entitled “Analyzing the Impact of Drivers' Experience with Electric Vehicles on the Intention to Use Electric Carsharing: A Qualitative Approach” (see Appendix 10), test drives with an electric vehicle are conducted and 24 end user subjects are surveyed. The analysis shows that the experience with an electric vehicle has a positive effect on the intention to use electric carsharing. In the paper “Ein Smartphone-Bonussystem zum energieeffizienten Fahren von Carsharing-Elektrofahrzeugen” (see Appendix 11), a conceptual design of a smartphone bonus system for energy-efficient driving of electric vehicles in carsharing fleets is developed. Various sorts of incentives and different carsharing user types are outlined, and opportunities of implementing a smartphone bonus system into a carsharing program are discussed. A first mockup is realized and presented in the paper, recommendations for automotive manufacturers, carsharing providers, and software developers are given, and technical possibilities with a focus on mobile operating sys-

tems and infotainment systems are examined. These three papers addressing the topic of electric carsharing were published in the “IWI Discussion Paper Series”.

Before starting his doctoral studies, within the frame of a student seminar that was held in Bremerhaven, Germany in 2010, the author developed a paper entitled “Mobile Infotainment – IT Solutions for Cruise Ships” (see Appendix 12). The paper was selected as one of the best student works and therefore was published in the book “Cruise Management – Information and Decision Support Systems”[5]. In the paper, the market for mobile infotainment solutions is analyzed, customer needs are investigated, and recommendations for the cruise industry are provided.

[5] http://www.springer.com/book/9783834932723

Table II. Overview of Publications

Appendix	Theme	Title	Authors	Conference/Journal/Book	Date	VHB/ WKWI*	VHB/ JQ3**
1	Information Security	Investigating the Influence of Security, Privacy, and Legal Concerns on Employees' Intention to Use BYOD Mobile Devices **(Winner of Best Conference Paper Award)**	Lebek, B., Degirmenci, K., Breitner, M. H.	Proceedings of the 19th Americas Conference on Information Systems (AMCIS), August 15-17, 2013, Chicago, IL, USA.	08/2013	B	D
2	Information Security	Bring Your Own Device: Cultural Differences of Employees' Intention to Use Personal Mobile Devices for Work	Degirmenci, K., Shim, J. P., Breitner, M. H.	Submitted to the MIS Quarterly	12/2015	A	A+
3	Information Privacy	Mobile Applications and Access to Personal Information: A Discussion of Users' Privacy Concerns	Degirmenci, K., Guhr, N., Breitner, M. H.	Proceedings of the 34th International Conference on Information Systems (ICIS), December 15-18, 2013, Milan, Italy.	12/2013	A	A
4	Electric Vehicles	How Can Mobile Applications Reduce Energy Consumption? An Experimental Investigation of Electric Vehicles	Degirmenci, K., Katolla, T. M., Breitner, M. H.	Proceedings of the 23rd European Conference on Information Systems (ECIS), May 26-29, 2015, Münster, Germany.	05/2015	A	B
5	Electric Vehicles	Market Introduction of Electric Cars: A SWOT Analysis	Völk, T., Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #63, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	07/2014		
6	Electric Vehicles	Elektromobilität in Deutschland und anderen Ländern: Vergleich von Akzeptanz und Verbreitung	Kaut, R., Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #68, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	09/2015		
7	Carsharing	Carsharing: A Literature Review and a Perspective for Information Systems Research	Degirmenci, K., Breitner, M. H.	Proceedings of the Multikonferenz Wirtschaftsinformatik (MKWI), February 26-28, 2014, Paderborn, Germany, pp. 962-979.	02/2014	C	D
8	Carsharing	A Systematic Literature Review of Carsharing Research: Concepts and Critical Success Factors	Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #69, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	09/2015		
9	Electric Carsharing	Gemeinschaftsgefühl und Motivationshintergrund: Eine qualitative Inhaltsanalyse im Bereich des Elektro-Carsharing	Baburi, M., Günther, K., Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #65, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	11/2014		
10	Electric Carsharing	Analyzing the Impact of Drivers' Experience with Electric Vehicles on the Intention to Use Electric Carsharing: A Qualitative Approach	Thiessen, M., Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #66, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	12/2014		
11	Electric Carsharing	Ein Smartphone-Bonussystem zum energieeffizienten Fahren von Carsharing-Elektrofahrzeugen	Kreutz, M., Lüpke, P., Kühne, K., Degirmenci, K., Breitner, M. H.	IWI Discussion Paper #71, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover.	12/2015		
12	Cruise Management	Mobile Infotainment – IT Solutions for Cruise Ships	Krause, C., Degirmenci, K.	Cruise Management – Information and Decision Support Systems, A. Papathanassis, M. H. Breitner, C. Schön, N. Guhr (eds.), Wiesbaden: Gabler, pp. 185-203.	2012		

*Assignment by the "Wissenschaftliche Kommission Wirtschaftsinformatik im Verband der Hochschullehrer für Betriebswirtschaft e. V." and the "Fachbereich Wirtschaftsinformatik der Gesellschaft für Informatik" in the WI-Orientationlists, cf. WKWI and GI-FB WI (2008)
** cf. VHB-JOURQUAL 3 (2015)

1. Introduction

1.1 Motivation, Scope, and Contribution

The proliferation of mobile information systems (IS) such as smartphones and tablets is continuously impacting individuals' daily lives due to the increasing need of anytime and anywhere accessibility (Adipat et al. 2011; Constantiou et al. 2014; Middleton et al. 2014; Picoto et al. 2014; van der Heijden and Junglas 2006). Advances in sensor technologies like built-in cameras, proximity sensors, accelerometers, gyroscopes, and Global Positioning System (GPS) receivers, allow diverse new possibilities regarding the mobile users' environment, movement, orientation, and location (Enck 2011; Keith et al. 2015; Lienhard and Legner 2015; Zhang et al. 2009). The penetration of mobile users has grown from one percent of the worldwide population in 1995 (80 million mobile users) to 73 percent in 2014 (5.2 billion mobile users), of which 40 percent are smartphone users (Meeker 2015). According to a forecast report by eMarketer (2014), the global share of smartphone users will continue to grow to 51.7 percent (2.56 billion) by 2018.

Despite the facilitation of various technology benefits, the use of mobile IS also entails several drawbacks, e.g., distinct aspects of security and privacy threats. From an organizational perspective, the implementation of mobile IS involves information security concerns (Beulen and Streng 2002; Giessmann et al. 2012; Scheepers and Scheepers 2004). For example, the trend of employees using their personal mobile devices for work purposes has emerged in the course of the consumerization of information technology (IT) in the past several years (Chen 2014; French et al. 2014; Harris et al. 2013). This trend, described as "bring your own device" (BYOD), enables employees the freedom to choose any device that best suit their individual needs and work requirements (Niehaves et al. 2012). However, it also endangers organizations concerning corporate data to be exposed to security threats such as malware intrusion and the possibility of corporate data loss and theft (Miller et al. 2012; Osterman

Research 2012). BYOD is a global phenomenon with international characteristics, which is why this doctoral thesis not only focuses on security considerations, but also on cultural aspects regarding a better understanding of employees' behavior toward BYOD for organizations acting in a multinational and multicultural environment. With regard to privacy aspects, the disclosure of personal information has been in the focus of several mobile IS research studies (e.g., Kehr et al. 2015; Sutanto et al. 2013). Particularly, mobile applications (apps) gain access to mobile users' personal information regarding their identity, location, and other sensitive data like contact lists, photos and videos, as well as text messages (Keith et al. 2015; Najjar and Bui 2012; Xu et al. 2012a, 2012b). Although the access to personal information can be advantageous for mobile users—for example, the access to location is used for navigation purposes—it also evokes privacy concerns with the result that users delete apps from their devices (Boyles et al. 2012; eMarketer 2016). For app providers, it is therefore important to understand and alleviate mobile users' information privacy concerns (MUIPC) (Xu et al. 2012a). Another aspect of this thesis covers an emerging topic that has come into consideration in IS research concerning IS for environmental sustainability (Elliot 2011; Hilpert et al. 2013; Ijab et al. 2012; Malhotra et al. 2013; Melville 2010; Watson et al. 2010). In the face of ongoing global warming and climate change, the integration of IS provides information about the environmental impact of personal decisions (Watson et al. 2012). The role of mobile IS as an integral part of IS for environmental sustainability has been discussed in this field (see, for example, Oppong-Tawiah et al. 2014; Pitt et al. 2011, von Mohrenfels and Klapper 2012). In this thesis, the focus is on electric vehicles (EVs) and how mobile IS can reduce energy consumption by deploying smartphone-based driver assistance systems.

This thesis addresses the research field of mobile IS and aspects of information security, information privacy, and environmental sustainability, and makes a theoretical contribution by conceptualizing the following:

(1) Employees' intention to use BYOD is influenced by cultural differences (security of mobile IS).
(2) Mobile users' privacy concerns are affected by mobile apps' access to personal information (privacy of mobile IS).
(3) Smartphone-based driver assistance systems have an impact on the energy consumption of EVs (mobile IS for environmental sustainability).

With regard to the first research study of this thesis, a review of the literature in the area of BYOD shows that most of the articles focus on behavior and security; the cultural aspects of BYOD, however, have drawn little attention. To analyze the cultural differences as an initial step, in this study the focus is on the United States (Anglo-American culture), Germany (Central European culture), and South Korea (Asian culture). These three nations have a similar, high percentage of smartphone users, with an expected share of 79.7 percent of mobile users in the United States, 80.0 percent in Germany, and 84.8 percent in South Korea by 2017 (McDermott 2013). Smartphones are considered to have the highest potential for BYOD usage (Cisco IBSG 2013). Furthermore, BYOD is a growing trend in the United States and Germany (Cisco IBSG 2013) as well as in South Korea (IDG Connect). This study attempts to offer recommendations for global organizations that are planning to implement a BYOD strategy in a multinational and multicultural context for cross-cultural communication.

Referring to the second research study, an increasing number of studies within IS research investigate mobile app security and privacy. In this study, it is proposed that the analysis of the influence of access to personal information on mobile users' privacy concerns contributes to the understanding of the antecedents of information privacy concerns. The study aims to contribute to this research gap and attempts to offer recommendations for app providers to better address the challenge of reducing users' concerns for information privacy when they wish to install and use mobile

apps. For example, Apple changed the privacy settings with the release of iOS 6 in September 2012 as a reaction to mobile users' privacy concerns. This change implies that not only can mobile users turn off access to location, they can also restrict access to contacts, calendars, reminders, photos, Bluetooth sharing, and access to Twitter and Facebook accounts if supported by the mobile app. Since the release of iOS 7, 8, and 9, users are able to control further categories such as the microphones and cameras of their mobile devices. On Google Android mobile devices with version 5.0 Lollipop or lower, it is not possible to control individual app permissions. Google followed the ability of iOS devices to turn off app permissions individually with the release of Android 6.0 Marshmallow in October 2015. App providers more and more face the challenge of both considering privacy concerns of their users and implementing measures to alleviate those concerns.

The third research study contributes to the emerging topic of IS for environmental sustainability by testing the influence of a mobile application on driving behavior. As a reaction to increasing carbon dioxide (CO_2) emissions, automotive manufacturer Toyota released a mobile application (app) called "A Glass of Water," which claims to lower energy consumption by 10 percent (Vandist 2011). The app creates a digital glass of water on the smartphone that helps the driver to drive more carefully by not spilling water. This kind of driver assistance system in the form of a mobile app has the task of warning the driver of excessive acceleration and braking (Guan and Frey 2012). Another smartphone-based driver assistance system called "Smooth Driver" from Jettysoft, an Australian software development company, claims that it monitors hard braking and acceleration (Apple 2014). The claims of Toyota and Jettysoft promise energy reduction through mobile apps, which can in turn help lower CO_2 emissions and increase range. Several studies reported a strong influence of the driving behavior on the energy consumption, with the result that aggressive driving increases energy consumption by about 40 percent in city traffic (see, e.g., de Vlieger

1997; Fonseca et al. 2010). In these studies, cars with a combustion engine were tested, and aggressive driving is defined by sudden acceleration and heavy braking.

1.2 Research Questions

Employees' intention to use BYOD is measured using the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989). In terms of security considerations, Pavlou et al.'s (2007) research model is adapted to measure the construct of perceived uncertainty, which is hypothesized to be related to employees' intention to use BYOD. Cultural differences of BYOD are explored following the cultural dimensions theory (Hofstede et al. 2010), which describes six cultural dimensions: power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. The study has a focus on the United States as a representative country for the Anglo-American culture, Germany on behalf of the Central European culture, and South Korea representing the Asian culture. A survey of 542 employees from these cultures is conducted in order to test hypothesized relationships of employees' intention to use and to analyze cultural differences. The following first research question is being explored:

> ***RQ1:*** *To what extent do cultural differences of bring your own device exist between American, German, and Korean employees' intention to use personal mobile devices for work?*

MUIPC is measured using three dimensions: perceived surveillance, perceived intrusion, and secondary use of personal information (Xu et al. 2012a). In order to measure access to personal information as an antecedent to MUIPC, permission requests of several mobile apps are systematically reviewed and analyzed. Upon the results of this app review and analysis, access to personal information is categorized into four dimensions: personal identity, location, device content, and system and network settings. The influence of these dimensions on MUIPC is tested with a structural equa-

tion model (SEM) by conducting a survey of 474 mobile app users. The following second research question is proposed:

RQ2: *Which type of access to personal information has a major influence on mobile users' privacy concerns?*

The impact of smartphone-based driver assistance systems on the energy consumption of EVs is measured by developing an experimental design. In this experimental design, a control group and a treatment group are defined, with a driver assistance system in the form of a mobile app as the treatment of the study. The mobile app monitors excessive acceleration and hard braking, which are considered as important factors for energy-efficient driving (de Vlieger 1997; Fonseca et al. 2010). The research study follows the presumption that IS provides information about the environmental impact of personal decisions (Watson et al. 2012) and it is thus assumed that smartphone-based driver assistance systems will significantly influence driving behavior and consequently reduce energy consumption. This leads to the third research question:

RQ3: *What impact do smartphone-based driver assistance systems have on the energy consumption of electric vehicles?*

1.3 Structure of the Thesis

This doctoral thesis is structured beginning with an abstract and a management summary. After presenting an overview of publications, the introduction in Chapter 1 motivates the overall topic of the thesis, sets the scope of the three research studies that are in focus, and describes how the studies contribute to IS research. Furthermore, the research questions of the studies are presented. The following three chapters address the research studies in focus. Chapter 2 examines security aspects of mobile IS ("Cultural Differences of Bring Your Own Device"), Chapter 3 investigates

privacy aspects (“Mobile Applications and Users’ Privacy Concerns”), and Chapter 4 deals with mobile IS for environmental sustainability (“Energy Reduction of Electric Vehicles through Mobile Applications”). In Chapter 5, overall conclusions and an outlook are given.

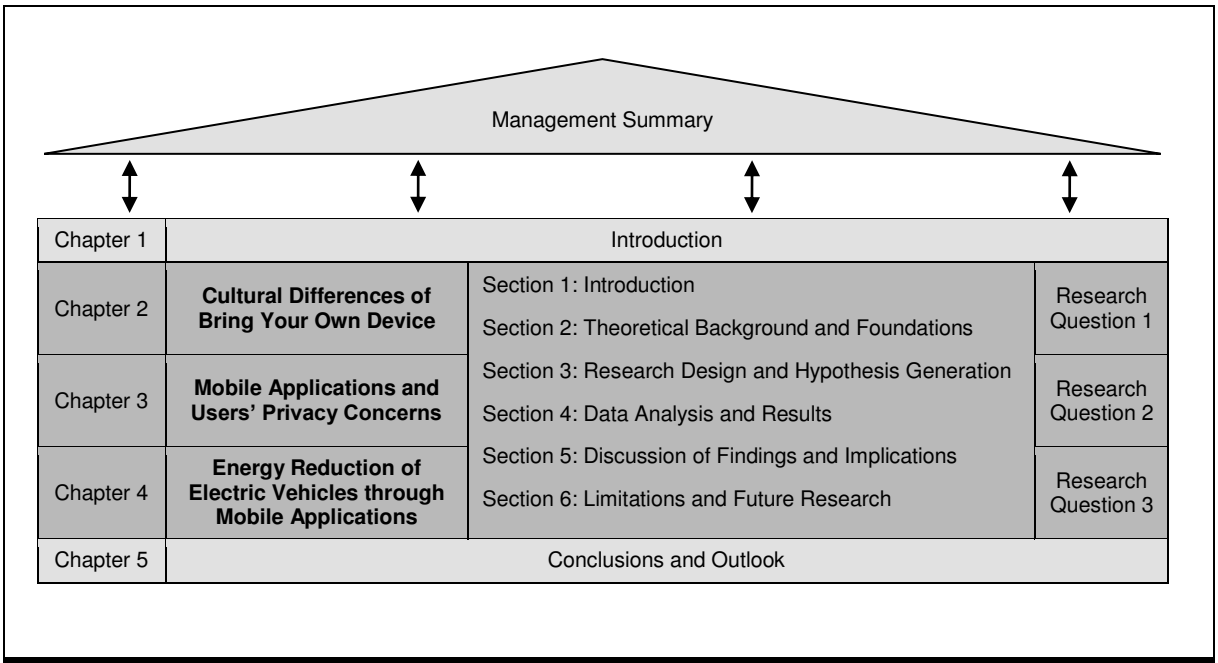

Figure 1. Structure of the Thesis

2. Cultural Differences of Bring Your Own Device

This chapter refers to the article “Investigating the Influence of Security, Privacy, and Legal Concerns on Employees’ Intention to Use BYOD Mobile Devices” (see Appendix 1). The author of this doctoral thesis presented the paper at the 19th Americas Conference on Information Systems (AMCIS) in Chicago, Illinois, USA (August 15-17, 2013). AMCIS is a conference of the Association for Information Systems (AIS) and is viewed as “one of the leading conferences for presenting the broadest variety of research done by and for IS/IT academicians in the Western Hemisphere.”[6] The paper was presented at the track “Information Systems Security, Assurance, and Privacy” and was honored with one out of five “Best Conference Paper” awards[7] from 15 nominees out of over 330 accepted submissions[8].

Based upon comments received at AMCIS, the paper has been significantly modified. The major substantial revisions include an analysis of cultural differences by adding the United States and South Korea as new cultures of focus to Germany. Due to time restrictions of the lead author of the AMCIS Paper, Dr. Benedikt Lebek (bhn Dienstleistungs GmbH & Co. KG) was not available to serve as second author of the revised paper. The AMCIS 2013 program chair, Prof. Dr. J. P. Shim (Georgia State University), who also focuses on BYOD research and published several research articles in this field, was asked to serve as second author, which he accepted. The revised paper entitled “Bring Your Own Device: Cultural Differences of Employees’ Intention to Use Personal Mobile Devices for Work” was submitted to the Management Information Systems Quarterly (MISQ), which is listed in the College of Senior Scholars basket of eight journals[9] and is often ranked the number one journal in the field of information systems[10]. The editorial objective of the MISQ is “the enhance-

[6] http://aisel.aisnet.org/amcis/
[7] http://aisnet.org/news/138824/Congratulations-to-the-AMCIS-2013-Award-Winners.htm
[8] http://amcis2013.aisnet.org/attachments/AMCIS2013WelcomeLetters-8.9.13.pdf
[9] https://aisnet.org/general/custom.asp?page=SeniorScholarBasket
[10] https://aisnet.org/?JournalRankings

ment and communication of knowledge concerning the development of IT-based services, the management of IT resources, and the use, impact, and economics of IT with managerial, organizational, and societal implications."[11] This chapter mainly reflects the manuscript that was submitted to MISQ.

2.1 Introduction

In information technology (IT) consumerization, "bring your own device" (BYOD) is described as the use of employees' privately owned information system (IS) devices for work purposes (Lee et al. 2013; Loose et al. 2013). BYOD devices are predicted to grow from 198 million in 2013 to 405 million by 2016 in global workplaces (Cisco IBSG 2013). According to a survey by the CyberEdge Group (2014), which was conducted in North America and Europe, more than 75 percent of responding organizations will have BYOD policies in place by 2016. In other regions, BYOD has also emerged, for example, IDG Connect (2014) surveyed 300 IT managers in Australia, India, South Korea, and Taiwan, and found out that only 9 percent of the organizations stated employees are not allowed to bring their own devices to work. BYOD is often linked to several advantages for both employees and organizations. From an employee's point of view, these are greater freedom and flexibility, increased motivation, as well as easier technology adoption (Niehaves et al. 2012). These benefits can lead to a higher job satisfaction (Osterman Research 2012). Since positive job satisfaction increases employees' productivity (Saari and Judge 2004), organizations can also benefit from BYOD (Dell 2011; Osterman Research 2012). The use of BYOD devices can increase employees' availability and thus the flexibility and mobility of the workforce when business needs occur. This flexibility allows employees to work from home or on the move with the result that business continuity does not suffer. These benefits provide an incentive for organizations to implement a BYOD strategy. A precondition for a successful BYOD implementation is understanding em-

[11] http://misq.org/about/

ployees' behavior toward BYOD, because an implementation usually depends on the employees' voluntary participation. However, BYOD creates a "unique set of challenges for IT professionals" (Johnson and Joshi 2012, p. 1) as it "redefines the relationship between employees […] and the IT organization" (Niehaves et al. 2012, p. 1). These challenges refer to instances such as the disadvantage of the added pressure of more workload at the expense of the private lives of employees (Chen 2014; Köffer et al. 2014; Loose et al. 2013; Niehaves et al. 2012). In addition, the implementation of a BYOD strategy can entail security threats, privacy concerns, and legal problems (Donaldson et al. 2015; Lebek et al. 2013; Miller et al. 2012; Osterman Research 2012; Silverglate and Salner 2011).

Due to the versatile and international scope of BYOD, this study investigates cultural differences of BYOD regarding employees' intention to use personal mobile devices for work, since mobile devices such as smartphones and tablets are most commonly used for BYOD practices (Cisco IBSG 2013). Cross-cultural challenges demand a structured comprehension of the differences, because "although the variety in people's minds is enormous, there is a structure in this variety that can serve as a basis for mutual understanding" (Hofstede et al. 2010, p. 4). Mature countries leading the IT sector were selected to explore more of the differences among cultures and how that plays a role as organizations incorporate BYOD: the United States as a representative country for the Anglo-American culture, Germany on behalf of the Central European culture, and South Korea representing the Asian culture. This study makes a theoretical contribution by conceptualizing employees' intention to use BYOD and by investigating cultural differences between the United States, Germany, and South Korea. The research question is as follows:

RQ: *To what extent do cultural differences of bring your own device exist between American, German, and Korean employees' intention to use personal mobile devices for work?*

2.2 Theoretical Background and Foundations

2.2.1 Bring Your Own Device in Information Systems Research

Following the literature search and analysis process guidelines by Webster and Watson (2002) and vom Brocke et al. (2009), a literature review on the topic of BYOD was conducted on six major IS research databases: ACM, AISeL, IEEE, Science Direct, EBSCOhost, and SpringerLink. The keywords “bring your own device” and “BYOD” were used to search titles of the relevant literature papers, which have a strong focus on IS research. The articles were identified in the proceedings of the Americas Conference on Information Systems (AMCIS), European Conference on Information Systems (ECIS), International Conference on Information Systems (ICIS), and Pacific Asia Conference on Information Systems (PACIS) and in the following journals: Business & Information Systems Engineering (BISE) and Communications of the Association for Information Systems (CAIS). The identified articles mainly deal with BYOD behavior and security issues. Further topics include BYOD in education, culture, status quo, and outcomes from BYOD (see Table 1).

As the purpose of this study is to examine cultural differences of employees’ intention to use BYOD, the cultural dimensions theory (Hofstede et al. 2010) is used for the focus countries (the United States, Germany, and South Korea) in order to set a theoretical foundation for cultural differences. Then, the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989) are used to develop the research model and generate the hypotheses.

Table 1. Overview of BYOD Literature in IS Research

Authors	Significant Findings	Outlet	Research Focus
Buettner 2015	Perceived enjoyment is found to be a significant predictor for the usage intensity of personal mobile devices for work.	AMCIS	Behavior
Chen 2014	A proposed research model is presented to measure the effects of flexibility and task complexity on BYOD intention (research-in-progress paper).	AMCIS	Behavior
French et al. 2014	A summary of a panel discussion at the AMCIS 2013 to the current status, issues, and future direction of BYOD.	CAIS	Status quo
French et al. 2015	Significant differences between the United States and South Korea regarding BYOD in class are found conducting a single factor ANOVA.	AMCIS	Education/ Culture
Harris et al. 2013	A survey of 131 college students shows that their mobile devices are poorly secured, which is why organizations are recommended to start with mobile device security awareness and training for BYOD.	AMCIS	Security
Hopkins et al. 2013	BYOD intention in class is substantially influenced by attitude and moderately influenced by subjective norm and perceived behavioral control.	ECIS	Education/ Behavior
Köffer et al. 2015	Results of a structural equation modeling show that BYOD usage significantly influences individual IT innovation behavior in the workplace.	BISE	Behavior
Lebek et al. 2013	Security, privacy, and legal concerns are found to be significant predictors for employees' intention to use BYOD.	AMCIS	Security/ Behavior
Lee et al. 2013	A proposed research model is presented to measure the impact of monitoring mechanisms, privacy concerns, and job performance expectancy on BYOD intention (research-in-progress paper).	ICIS	Behavior
Loose et al. 2013	BYOD intention is found to be a significant predictor for the attractiveness of a company for future employees offering the possibility to use personal mobile devices for work.	AMCIS	Behavior
Ortbach 2015	Personal innovativeness significantly influences perceived ease of use of privately owned and company-owned devices; perceived usefulness of privately owned devices is the most important predictor for BYOD intention.	ECIS	Behavior
Ortbach et al. 2015	A proposed survey of IS executives is presented that will investigate the effects of trust and risk on BYOD policy decisions, which in turn influences IS service quality (research-in-progress paper).	ECIS	Security
Putri and Hovav 2014	Employees' compliance with BYOD security policy is significantly affected by perceived response efficacy.	ECIS	Security
Tu and Yuan 2015	A survey of IS executives will be conducted to identify factors affecting organizations' coping with BYOD security threat (research-in-progress paper).	AMCIS	Security
Weeger and Gewald 2014	Perceived risk, perceived benefits, and personal innovativeness are found to be significant predictors of BYOD intention.	ECIS	Security/ Behavior
Yin et al. 2014	The authors plan to conduct interviews with employees and executives about benefits, costs, expectations, goals, and outcomes of BYOD followed by a survey for hierarchical linear modeling (research-in-progress paper).	PACIS	Outcomes

2.2.2 Cultural Dimensions Theory

In the cultural dimensions theory, culture is classified into six categories: power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence (Hofstede et al. 2010). Figure 2 shows the culture scores for the United States, Germany, and South Korea, with a range from 0 to 100. The scores are relative, meaning that culture can be only used meaningfully by comparison (Hofstede et al. 2010).

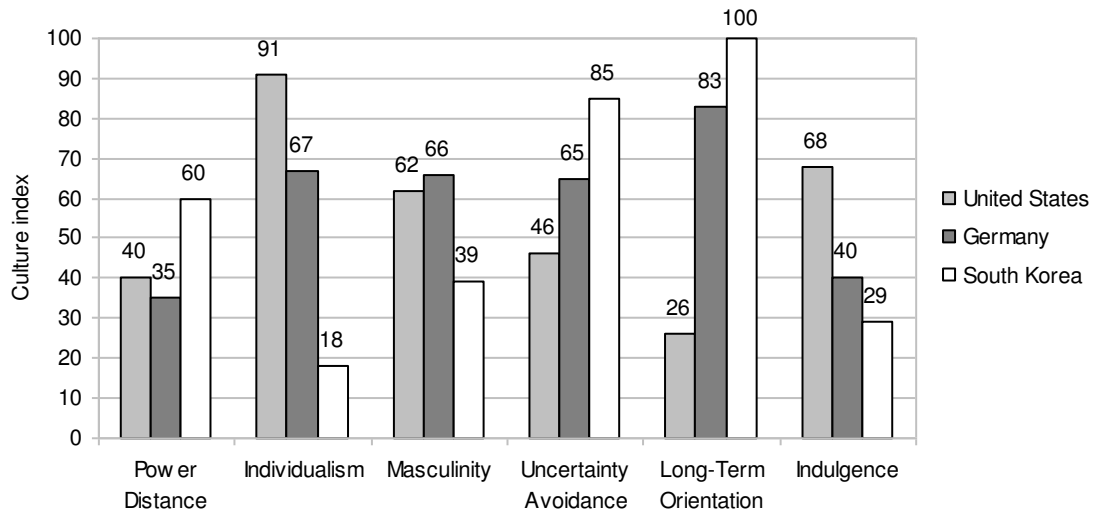

Figure 2. Cultural Dimensions for the United States, Germany, and South Korea

Power distance is defined as "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" (Hofstede et al. 2010, p. 61). Within the context of BYOD, power distance may imply that employees expect to be consulted whether BYOD should be implemented (low power distance) or employees expect to be told what to do (high power distance). Thus, employees' attitude toward BYOD is assumed to be less important for high power distance cultures, because employees' intention to bring their own devices will not mainly depend on their attitude.

Individualism refers to "societies in which the ties between individuals are loose: everyone is expected to look after him- or herself and his or her immediate family. Collectivism as its opposite counterpart, pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty" (Hofstede et al. 2010, p. 92). Hofstede et al. also point out that there is a negative correlation between power distance and individualism. Many countries with a high score on power distance score low on individualism, which is the case for the United States, Germany, and South Korea (see Figure 2). Individualist countries place importance on free-

dom, independence, and individual interests, whereas collectivist countries value equality, interdependency, and collective interests. With regard to BYOD, individualism may imply that employees prefer the freedom to use their own devices without being dependent on systems provided by the organization. In contrast, collectivism may imply that employees prefer equality to the effect that all employees use the same device provided by the organization. There could be a propensity for being interdependent with the organization's processes and structure, which also suggests a preference for company devices in collectivist countries. Employees from collectivist countries may prioritize the organization's intention to implement BYOD policies over the risk of running into security issues with corporate data such as data theft or loss of device, disclosing personal information such as personal profiles on social networks, personal emails, and personal photos, or experiencing legal complications regarding work time regulations, accounts of charges, or commitment to maintenance.

Masculine and feminine societies are defined as follows: "A society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap: both men and women are supposed to be modest, tender, and concerned with the quality of life" (Hofstede et al. 2010, p. 140). BYOD encourages to increasing productivity by work−life blending enabled by the usage of personal devices for work purposes. Thus, masculine cultures are assumed to prefer BYOD in order to increase performance and achieve material success, whereas feminine countries would rather decline BYOD due to a distinct separation of work hours and leisure time supporting work−life balance for an enhanced quality of life.

Uncertainty avoidance is defined as “the extent to which the members of a culture feel threatened by ambiguous or unknown situations. This feeling is, among other manifestations, expressed through nervous stress and in a need for predictability: a need for written and unwritten rules” (Hofstede et al. 2010, p. 191). Hofstede et al. clarify that uncertainty avoidance should not be confused with risk avoidance, but rather that uncertainty-avoiding cultures are often prepared to engage in risky behavior in order to reduce ambiguities. For example, stronger uncertainty avoidance can lead to faster driving, taking a familiar risk to reduce ambiguity. Thus, in uncertainty-avoiding cultures there is a sense of stress and urgency. As a consequence, uncertainty-avoiding cultures may take the risk of implementing BYOD in order to increase urgency and to save time while simultaneously, meeting the need for precise rules. In this instance, BYOD policies clearly define principles and guidelines for the usage of personal devices for work purposes.

Long-term orientation describes “the fostering of virtues oriented toward future rewards—in particular, perseverance and thrift. Its opposite pole, short-term orientation, stands for the fostering of virtues related to the past and present—in particular, respect for tradition, preservation of ‘face,’ and fulfilling social obligations” (Hofstede et al. 2010, p. 239). One major distinction in the work environment between long-term and short-term oriented cultures is the importance of leisure time and the perspective of work−life balance. While short-term oriented cultures consider leisure time to be important, it is of less importance for long-term oriented cultures. Furthermore, in long-term oriented cultures, family and work are not separated. Similar to the dimension of masculinity, long-term oriented cultures encourage work−life blending, while short-term oriented cultures strive for work−life balance. This is further emphasized by the concept of *guanxi*, which describes the necessity of a personal network of acquaintances for success in Chinese society. *Guanxi* refers to personal connections, linking the family sphere to the business sphere. The work−life blending characteristic of *guanxi* is similar to BYOD, allowing personal contacts to be interwoven into

business needs. Employees' perceived benefits of BYOD are assumed be more important for long-term oriented cultures.

Indulgence stands for "a tendency to allow relatively free gratification of basic and natural human desires related to enjoying life and having fun. Its opposite pole, restraint, reflects a conviction that such gratification needs to be curbed and regulated by strict social norms" (Hofstede et al. 2010, p. 281). Besides life satisfaction and happiness, the importance of leisure is one distinct characteristic, which differentiates indulgent societies from restraint societies. Hofstede et al. also point out that in indulgent societies, email and the Internet are more frequently used for private contacts. In terms of BYOD, using personal devices for work purposes could implicate an intrusion in employees' leisure time and quality of life due to employees' increase in workload. On the other hand, BYOD entails the communication with private contacts during work hours. Consequently, employees from indulgent cultures could refuse to use BYOD due to an intrusion into leisure time, but simultaneously could endorse BYOD due to the opportunity to communicate with private contacts during work hours.

Table 2 summarizes the cultural dimensions and the assumed impacts they can have on employees' BYOD intention. Since the blending of work and life is one major characteristic of BYOD, according to the assumptions made, cultural differences regarding work−life balance can have a major impact on employees' intention to use BYOD. Besides the work−life balance, further aspects should be taken into consideration, for example, the values of freedom and equality, the pursuit of material success and quality of life, the need for urgency, and the importance of leisure.

Table 2. Assumptions for Cultural Influence on BYOD Intention			
Cultural Dimension	**Degree**	**Assumption**	**BYOD Intention**
Power Distance Index (PDI)	High PDI	Employees' attitude less important	o
	Low PDI	Employees' attitude important	o
Individualism versus Collectivism (IDV)	Individualism	Freedom to use own devices	+
		Independent of corporate system	+
		High concerns due to individual interests	-
	Collectivism	Preference for corporate device (equality)	-
		Interdependent with organization	-
		Low concerns due to collective interests	+
Masculinity versus Femininity (MAS)	Masculinity	Work−life blending (material success)	+
	Femininity	Work−life balance (quality of life)	-
Uncertainty Avoidance Index (UAI)	High UAI	Work−life blending (need for urgency)	+
		BYOD policies important (need for precise rules)	o
	Low UAI	Work−life balance (relaxed behavior)	-
		BYOD policies less important (tolerance for ambiguity)	o
Long-Term Orientation versus Short-Term Orientation (LTO)	LTO	Work−life blending (lifelong personal networks)	+
	STO	Work−life balance (variation of personal networks)	-
Indulgence versus Restraint (IVR)	Indulgence	High importance of leisure	-
		Email and Internet used for private contacts	+
	Restraint	Low importance of leisure	+
		Less use of email and Internet for private contacts	-
Legend: + (positive influence on BYOD intention), o (neutral influence), - (negative influence)			

2.3 Research Design and Hypothesis Generation

The research model of this study is developed based on the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989). According to TRA, the most important predictor of an individual's behavior is the intention to perform the behavior (Fishbein and Ajzen 1975). Behavioral intention is defined as an indication "of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen 1991, p. 181). The most immediate antecedent of behavioral intention is attitude (Fishbein and Ajzen 1975), which is assumed to be "determined by salient beliefs regarding the consequences of performing the behavior, each belief multiplied by the subjective value of the consequences in question [evaluations]" (Ajzen and Fishbein 2008, p. 2224). Behavioral intention is also expected to be influenced by the subjec-

tive norm, which refers to “the perceived social pressure to perform or not to perform the behavior” (Ajzen 1991, p. 188) and is determined by “the perceived expectations of specific referent individuals or groups [normative beliefs], and by the person’s motivation to comply with those expectations” (Fishbein and Ajzen 1975, p. 302) (see Figure 3).

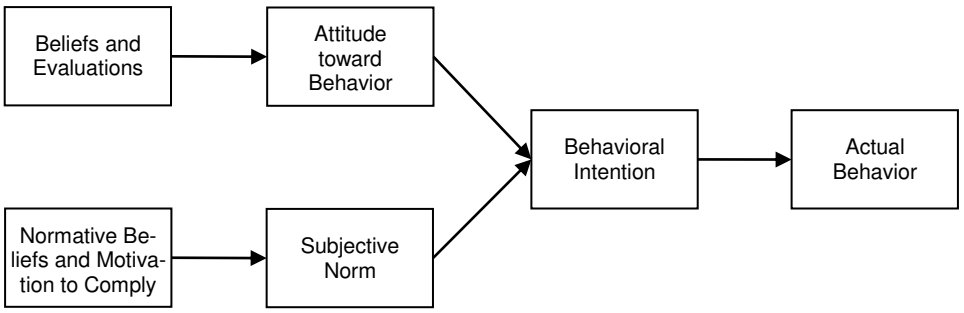

Figure 3. Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975)

TAM, which is an adaptation of TRA and considerably less general, is specifically designed to apply only to computer usage behavior, which is mainly explained by the perceived usefulness and perceived ease of use of information systems (Davis et al. 1989). Within an organizational context, perceived usefulness is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis 1989, p. 320). It is postulated that perceived usefulness affects attitude due to positively or negatively valued outcomes and has a direct influence on intention, because “within organizational settings, people form intentions toward behaviors they believe will increase their job performance, over and above whatever positive or negative feelings may be evoked toward the behavior per se” (Davis et al. 1989, p. 986). Perceived ease of use refers to “the degree to which a person believes that using a particular system would be free of effort” (Davis 1989, p. 320). The perceived usefulness and ease of use of information systems are affected by external variables such as system, user, task, process, and organizational characteristics (Davis et al. 1989) (see Figure 4).

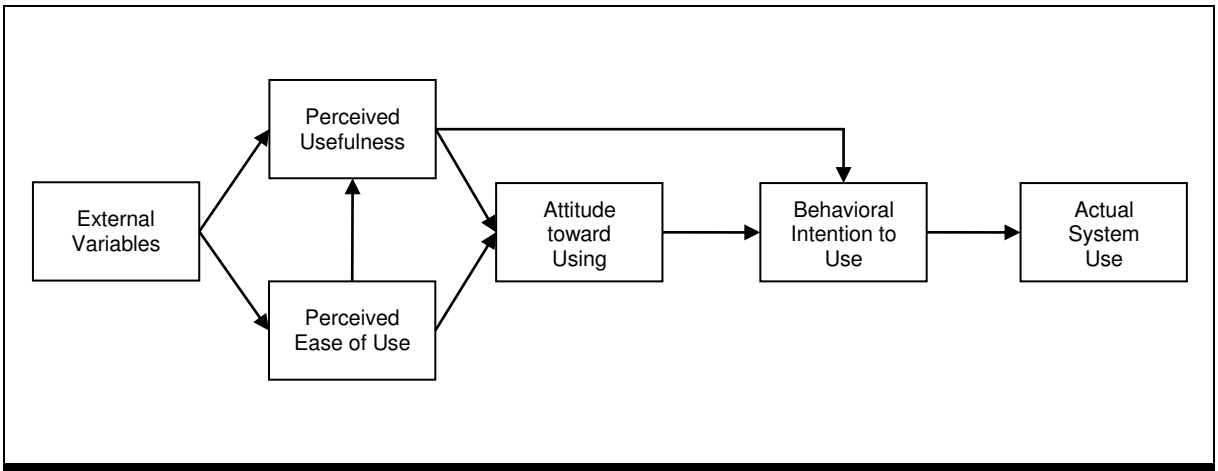

Figure 4. Technology Acceptance Model (TAM) (Davis et al. 1989)

In this study, the behavior is the actual usage of BYOD mobile devices and the focus is on security and cultural aspects, which is why subjective norm and perceived ease of use are not further considered. Concerning cultural differences among the United States, Germany, and South Korea, the following hypothesis is proposed:

H1: *The positive relationship between BYOD attitude and intention to use will be significantly different for American, German, and Korean employees.*

Regarding to beliefs and evaluations that affect the attitude toward the behavior, Oliver and Bearden (1985) distinguish between perceived benefits and perceived problems. With regard to benefits, BYOD entails advantages including the freedom to choose any device, an easier technology adoption, and an increased workforce availability when business needs occur. In view of problems within the frame of organizational IT, the construct of perceived uncertainty has been in the focus of several studies (e.g., Harnesk and Lindström 2011; Spears and Barki 2010). Perceived uncertainty can be defined as “the degree to which the future states of the environment cannot be accurately anticipated or predicted due to imperfect information” (Pavlou et al. 2007, p. 107). Considering the usage of BYOD mobile devices, perceived usefulness is defined as perceived benefits and perceived problems as per-

ceived uncertainty and these constructs are adapted to the research model in a cultural setting.

H2: *The positive relationship between perceived benefits of BYOD and (a) attitude and (b) intention to use will be significantly different for American, German, and Korean employees.*

H3: *The negative relationship between perceived uncertainty of BYOD and attitude will be significantly different for American, German, and Korean employees.*

Pavlou et al. (2007) propose that perceived uncertainty is influenced by security concerns and privacy concerns. In the context of BYOD, legal concerns are considered to be a third factor influencing uncertainty (Miller et al. 2012; Osterman Research 2012; Silverglate and Salner 2011). Security concerns can be defined as "the level to which an employee believes that her/his organizational information assets are threatened" (Herath and Rao 2009, p. 111). With the use of BYOD mobile devices, corporate information security is exposed to new risks (Niehaves et al. 2012; Tu and Yuan 2012). In contrast to company-owned devices, privately owned devices provide a greater likelihood of potential violations of the corporate information security policies, as regulations cannot usually be enforced on those devices (Miller et al. 2012; Osterman Research 2012). This results in two general threats to corporate information security: On the one hand, the integration of privately owned devices into corporate network facilitates malware intrusion (e.g., viruses, worms, trojans). On the other hand, it also increases the possibility of data loss and theft (Miller et al. 2012). In terms of privacy concerns, Minch (2004) defines privacy as "the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others" (p. 2). These concerns are related to a "possible loss of privacy as a result of information disclosure" (Xu et al. 2008,

p. 4). Mobile users may be afraid of being tracked and may worry that private data on their devices can be abused (Ho 2009). In the context of BYOD, the installation of mobile device management and mobile application management software may be required to secure (e.g., virus protection), monitor, manage (e.g., data synchronization), and support BYOD mobile devices. This is why organizations could be able to track employees' locations during work and non-work hours, which applications they have installed, and access personal data such as private emails and private photos (PR Newswire 2012). In addition to security and privacy concerns, BYOD is also associated with legal concerns (Osterman Research 2012; Silverglate and Salner 2011). In this study, legal concerns refer to existing statutory regulations between employers and employees. For example, Silverglate and Salner (2011) indicate that the use of BYOD mobile devices causes violations of work hour regulations as employees "stay connected to their jobs on nights, weekends and even vacations" (p. 41). As a consequence employees could demand compensation for their expanded work time (Silverglate and Salner 2011). Furthermore, it is assumed that employees are concerned about being held liable if corporate information is lost due to loss, theft or damage to their device. Due to the importance of security, privacy, and legal concerns regarding BYOD, the following hypothesis is proposed, taking account of cultural differences between the United States, Germany, and South Korea:

H4: *The positive relationship between perceived uncertainty of BYOD and (a) security concerns, (b) privacy concerns, and (c) legal concerns will be significantly different for American, German, and Korean employees.*

For the empirical exploration, a survey was designed and distributed to participants from the United States, Germany, and South Korea via an online survey (via social networking sites, email, and personal recruitment through professional networking) and written submissions. The first two questions were designed to eliminate participants who were neither employed nor privately owning a mobile device. These re-

strictions concerning the target group allowed to accurately measure the hypothesized constructs. To reduce bias, the questionnaire was provided in the English, German, and Korean languages (see Appendix 2 Table A1 for the survey instrument). Prior to the main test, seven pretests were conducted. The pretests were realized by means of intensive discussions with the participants in order to receive feedback concerning the validity and comprehensibility of the survey questions. Multiple item constructs were chosen using a five-point Likert scale, which ranged from "strongly disagree" to "strongly agree." In total, 542 participants (i.e., employees from major cities in the United States, Germany, and South Korea) produced usable data, with 210 from the United States, 178 from Germany, and 154 from South Korea (see Appendix 2 Table A2 for the profiles of responding participants).

2.4 Data Analysis and Results

To test the proposed research model, structural equation modeling (SEM) was conducted using SmartPLS version 2.0.M3 (Ringle et al. 2005). All indicators were modeled as being reflective of their respective constructs. The measurement items in the model of this study load higher than the recommended value of 0.60 (Chin 1998), with loadings between 0.68 and 0.95 on their respective constructs and cross loadings did not pose a problem (see Appendix 2 Table B1 for loadings and cross loadings). The internal consistency of the scales was validated with the analysis of Cronbach's alpha ranging from 0.87 to 0.95, and composite reliability (CR) ranging from 0.91 to 0.96. To establish acceptable model reliability, the recommended values for construct reliability are above 0.70 (Gefen et al. 2000). An indicator for convergent and discriminant validity is the average variance extracted (AVE), which ranges from 0.72 to 0.88. Fornell and Larcker (1981) recommend a lower limit of 0.50 for convergent validity.

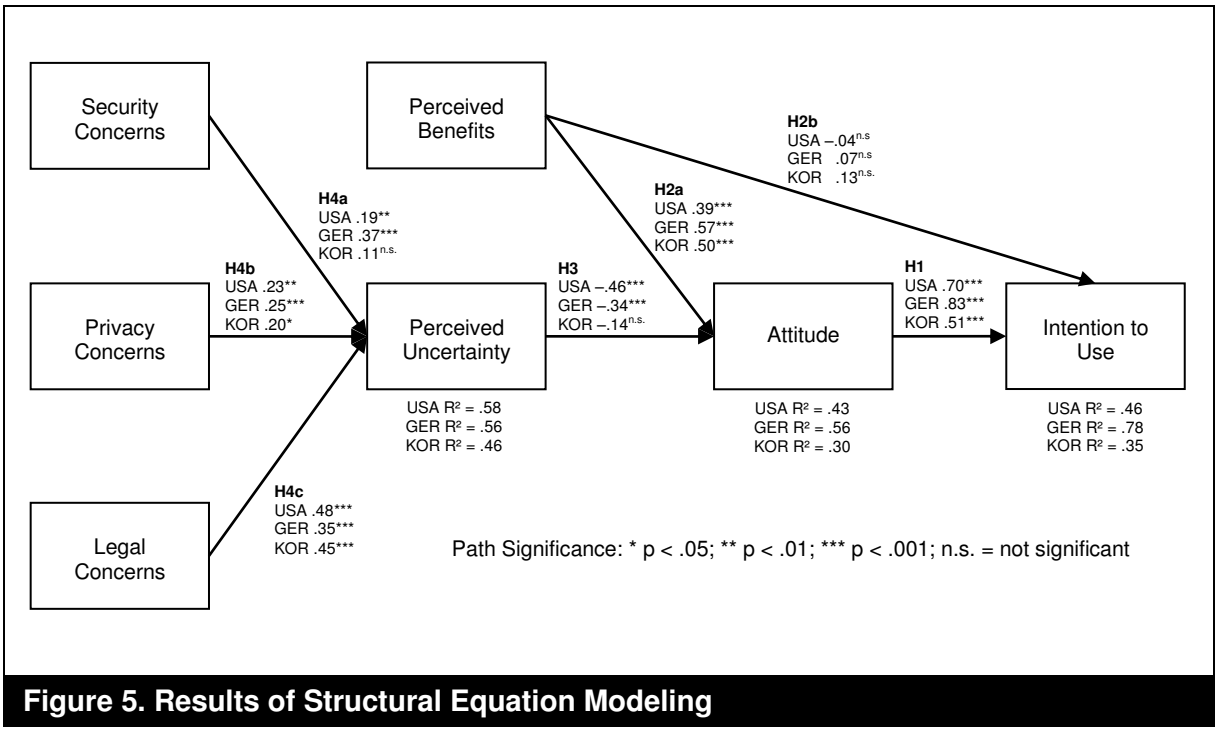

Figure 5. Results of Structural Equation Modeling

The corresponding path coefficients in the structural equation modeling were statistically compared to examine hypotheses on cultural differences (see Appendix 2 Table B2 for all path coefficients, t-values, and standard errors). The t-values for the differences among the United States, Germany, and South Korea have been calculated using the following formula provided by Keil et al. (2000):

$$S_{pooled} = \sqrt{\frac{N_1 - 1}{N_1 + N_2 - 2} \cdot SE_1^{\,2} + \frac{N_2 - 1}{N_1 + N_2 - 2} \cdot SE_2^{\,2}} \qquad (1)$$

$$t = \frac{PC_1 - PC_2}{S_{pooled} \cdot \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} \qquad (2)$$

where S_{pooled} = pooled estimator for the variance

t = t-statistics with $N_1 + N_2 - 2$ degrees of freedom

N_i = sample size of dataset for culture i

SE_i = standard error of path in structural equation modeling of culture i

PC_i = path coefficient in structural equation modeling of culture i

The results of the statistical calculations show that all path coefficients are significantly different between the United States, Germany, and South Korea, with t-values ranging from –2.93 to –43.90, thus, all hypotheses are supported (see Appendix 2 Table 4 for the statistical testing for differences). The path comparison of perceived uncertainty to attitude (H3) scored the highest t-value regarding statistical differences between the United States and South Korea ($t = –43.90$, $p < 0.001$), resulting in the largest statistical difference. A closer look at the path coefficients from perceived uncertainty to attitude emphasizes this result, with a significant influence for the United States ($\beta = –0.46$, $p < 0.001$), a significant influence for Germany ($\beta = –0.34$, $p < 0.001$), and no significant influence for South Korea ($\beta = –0.14$, $p > 0.05$), which is the most distinguishing characteristic in the structural equation modeling. The second highest t-value ($t = 42.79$, $p < 0.001$) was found for Germany and South Korea regarding the path comparison of attitude to intention to use (H1). While the path coefficient from attitude to intention to use is high for Germany ($\beta = 0.83$, $p < 0.001$) as well as for the United States ($\beta = 0.70$, $p < 0.001$), the path coefficient for South Korea is medium ($\beta = 0.51$, $p < 0.001$). Relatively low t-values were found for the path comparison of privacy concerns to perceived uncertainty (H4b) for the United States and Germany ($t = –2.93$, $p < 0.01$), the United States and South Korea ($t = 3.45$, $p < 0.001$), and for Germany and South Korea ($t = 5.94$, $p < 0.001$), with densely lying path coefficients of $\beta = 0.23$ ($p < 0.01$) for the United States, $\beta = 0.25$ ($p < 0.001$) for Germany, and $\beta = 0.20$ ($p < 0.05$) for South Korea, showing rather minor statistical differences. Considering the path comparison of security concerns to perceived uncertainty (H4a) as well as legal concerns to perceived uncertainty (H4c), the measured values of the path coefficients of the United States and South Korea lie close together with rather minor statistical differences, whereas Germany shows a rather higher path coefficient from security concerns to perceived uncertainty and a rather lower path coefficient from legal concerns to perceived uncertainty.

2.5 Discussion of Findings and Implications

In terms of employees bringing their personal mobile devices to work, employees from individualist cultures evoke high concerns due to individual interests. Mobile devices are considered to be “an expression of our personality” (Meschtscherjakov 2009, p. 1) and usually contain various information about the user’s identity. Thus, integrating a personal mobile device with all its personal information into the business environment can lead to high concerns in individualist cultures due to the ambition to protect personal information and thus individual interests. On the contrary, employees from collectivist cultures would rather prioritize collective interests such as the organization’s interest to implement BYOD above individual interests regarding the liability of loss of corporate data, possible disclosure of personal information, or risk of legal issues. Uncertainty-avoiding cultures, which are characterized with a need for precise rules, could be concerned with using personal devices for work purposes unless there are precise BOYD policies. Considering the results, the effect of individualism clearly appears to surpass the moderating effect of uncertainty avoidance on the influence of perceived uncertainty on attitude. Considering the influence of perceived benefits on attitude, other cultural factors appear to override the benefits of freedom and independence individualist employees can perceive bringing their own devices to work. Both Germany and South Korea are uncertainty-avoiding cultures, which entails the need for stress and urgency that are typical characteristics of work−life blending, thus having a positive moderating effect on the influence of perceived benefits on attitude. Cultures with low uncertainty avoidance, like the United States, having a score below average, rather favor relaxed behavior, which suggests work−life balance and thus the rejection of BYOD. Work−life blending is also encouraged in masculine cultures due to the pursuit of material success rather than quality of life and thus work−life balance, which is why German participants of the survey might place more importance on BYOD benefits than Korean participants. Long-term oriented cultures also promote work−life blending due to the importance of private contacts for business needs. Indulgence and restraint might have a moderating effect on

the influence of perceived benefits on attitude, because indulgent cultures place importance on leisure and would rather refuse BYOD, but simultaneously use email and the Internet more frequently for private contacts, which again supports the use of BYOD. Due to the results, it is concluded that the work−life blending characteristics of uncertainty avoiding, masculine, and long-term oriented cultures prevail over moderating effects of individualism and indulgence. With regard to the cultural dimension of power distance, the results support Hofstede et al.'s (2010) proposition that in high power distance cultures, employees are expected to be told what to do, no matter what their attitudes may be, and in low power distance cultures employees expect to be consulted. For Germany as a culture with low power distance, there lies the highest influence of attitude on behavioral intention, followed by the United States; South Korea, as a culture with higher power distance, has the lowest influence.

The proposed moderating effects of the cultural dimensions suggest further research of cross-cultural considerations, not only taking survey items from TRA and TAM, but also including items from Hofstede et al.'s (2010) cultural dimensions theory survey instrument in order to test the proposed moderating effects. For example, the moderating effect of power distance on the influence of attitude on intention could be analyzed by surveying participants whether they would favor the idea of bringing their personal devices to work and if they would intend to do so. The moderating effect will then be tested by further surveying if they would find it important to be consulted whether BYOD should be implemented in the organization for which they are working. The results of the study show that the employees' perceived uncertainty toward BYOD is largely due to security, privacy, and legal concerns. Here again, cultural differences exist, but regional conditions with regard to social, economic, technological, political, and legal conditions can also affect antecedents to perceived uncertainty toward BYOD. For example, considering the results, the perceived uncertainty of American employees is mainly affected by legal concerns. This may be due to the fact that legal disputes can be a big issue in the United States. Another example is

that Germany is a security-sensitive country, which is supported by the results, because the perceived uncertainty of German employees is mainly affected by security concerns. In order to further investigate antecedents of perceived uncertainty toward BYOD, employees from different cultures of interest could be interviewed to reveal why they feel uncertain about bringing their own devices to work. Other relationships of the model could also be investigated by interviewing employees to gain deeper insights of employees' BYOD behavior and cultural differences. Further research is also recommended to investigate the degree to which the integration of BYOD into the organization actually would increase employees' productivity and job satisfaction. Another aspect would be to examine the extent to which an integration actually would be cost-cutting for organizations, as costs may accrue, for example, due to the implementation of mobile device management software. Moreover, it would be interesting to see how the potential for employer control of employees' personal devices via mobile device management might impact the employees' perceived concerns.

The results of this study provide practical implications for organizations that are planning to implement a BYOD strategy. Organizations are dependent on employees' willingness to participate since BYOD is voluntary. Consequently, the understanding of employees' behavior is crucial for implementing BYOD strategies. If organizations plan to implement a BYOD program, employees' attitude toward BYOD must be considered, because attitude is the main driver of intention to use. This study shows that an increase in employees' perceived benefits of bringing personal devices to work and a reduction of perceived uncertainty will significantly influence employees' attitudes and thus BYOD intention. However, a diverse and cross-cultural communication for organizations to their employees is suggested when planning to implement BYOD due to the findings of cultural differences. For cultures that place importance on perceived benefits, such as Germany and South Korea, organizations should emphasize the advantages of BYOD. For cultures that consider perceived uncertainty important, such as the United States, organizations should focus on providing a se-

cure infrastructure that allows employees to create, store, and manage corporate data from anywhere at any time using BYOD devices. Privacy policies and a legal framework are also needed to minimize employees' uncertainty. In particular, uncertainty-avoiding cultures like South Korea and Germany also need precise rules, such as BYOD policies, in order to reduce ambiguity. Referring to the influence of attitude on the intention to use, especially organizations from low power distant cultures should involve employees when implementing BYOD.

2.6 Limitations and Future Research

The first limitation relates to the sample used for this study, as it consists of American, German, and South Korean employees. Consequently, differences only in these three cultures are controlled. Leidner and Kayworth (2006) showed that national culture significantly impacts IS studies. The results of this study can only be generalized to other cultures with caution. This study revealed that cultural differences can be of particular importance when analyzing the employees' intention to use BYOD. Future research is needed to focus on additional cultures to either control our results by choosing similar cultures or different cultures in order to uncover new aspects. In terms of generalizability, another bias possibility is self-selection among the survey respondents (Kankanhalli et al. 2005). The topic of the questionnaire revealed that the survey was about using personal mobile devices for work purposes. Participants who responded to this survey may be those who are more likely to endorse BYOD. These participants may also tend to be less concerned about the uncertainty of bringing their own devices to work.

Considering the cultural dimensions theory, the characteristics of the cultural dimensions, the cultural scores of the countries, and the conclusions derived from the theory should be viewed as a point of reference with the presumed condition that the domestic population of a country is a homogeneous whole (Jones and Alony 2007). However, nations are considered to be groups of ethnic units, which can be culturally

different within nations (Myers and Tan 2002). This also applies to organizations in which the cultures can be distinguished from one another within nations, which is why organizations that plan to implement BYOD should refer to the cultural dimensions theory as a guiding principle with the limitation that organizational culture can be distinct from national culture. Furthermore, the assumptions of this study for an impact of cultural differences on the intention to use BYOD relate to a deduction of propositions from the cultural dimensions theory in the BYOD context. Therefore, care must be taken when applying these assumptions due to a potential limitation in terms of comprehensiveness and adequate accuracy. Future researchers should empirically investigate the scope and preciseness of the applicability of the cultural dimensions for BYOD implementation. For this reason, qualitative research method of existential phenomenology could be conducted by performing employee interviews or focus group discussions in order to control the assumptions presented in this study and also identify further assumptions, which have not yet been addressed.

3. Mobile Applications and Users' Privacy Concerns

This chapter is based on the article "Mobile Applications and Access to Personal Information: A Discussion of Users' Privacy Concerns" (see Appendix 3). The paper was presented by the author of this doctoral thesis at the 34th International Conference on Information Systems (ICIS) in Milan, Italy (December 15-18, 2013). ICIS is the major annual meeting of the Association for Information Systems (AIS) and it is considered "the most prestigious gathering of information systems academics and research-oriented practitioners in the world."[12] In total, 1,537 registered for attendance at ICIS 2013.[13] The paper discussed in this chapter was presented at the track "Security and Privacy of Information and IS" and it was published in the conference proceedings.

3.1 Introduction

Mobile applications (apps) have become highly popular and will continue to generate revenues from pay-per-download, in-app purchase, subscriptions, and in-app advertising, growing from $8.5 billion in 2011 to $46 billion in 2016 (ABI Research 2012). Since the access to certain functions of mobile devices is needed to make full use of their potential, the use of mobile apps is often associated with privacy concerns (Keith et al. 2012; Soper 2012; Xu et al. 2012a). For example, the Google Maps mobile app requests access to the Global Positioning System (GPS) receiver of mobile devices to provide users with its navigation system, and as a result, a user's location is exposed. While this function is fundamental for the functioning of the navigation system of the Google Maps mobile app, access is requested unnecessarily in a number of cases (Enck 2011). Access to personal information, i.e., personal identity, location, device content, and system and network settings, can incite users not to install or to uninstall mobile apps. In a survey of 714 mobile app users, the Pew Re-

[12] http://aisel.aisnet.org/icis/
[13] http://icis2013.aisnet.org/

search Center found that 54 percent of the respondents had decided not to install and 30 percent had decided to uninstall mobile apps due to privacy concerns about their personal information (Boyles et al. 2012). Mobile users fear their personal information are misused by malicious apps, which are predicted to proliferate quickly on mobile platforms (Leavitt 2011).

The purpose of this study is to investigate how access to personal information affects mobile users' information privacy concerns (MUIPC). MUIPC is measured using three dimensions: perceived surveillance, perceived intrusion, and secondary use of personal information (Xu et al. 2012a). Following Smith et al. (1996), Stewart and Segars (2002) called for research investigating antecedents and consequences of information privacy concerns. In this study, the focus is on access to personal information as an antecedent to mobile users' privacy concerns. This approach attempts to offer recommendations for app providers to better address the challenge of reducing users' concerns for information privacy when they wish to install and use mobile apps. This study makes a theoretical contribution by conceptualizing that mobile users' privacy concerns are noticeably affected by access to their personal information. The following research question will be explored:

RQ: *Which type of access to personal information has a major influence on mobile users' privacy concerns?*

3.2 Theoretical Background and Foundations

3.2.1 Mobile Applications in Information Systems Research

Since over the past years new literature on the topic of mobile applications has vastly emerged, the literature review conducted by Degirmenci et al. (2013) has been updated according to the guidelines by Webster and Watson (2002) and vom Brocke et al. (2009). Six major IS research databases were searched: ACM, AISeL, IEEE, Sci-

ence Direct, EBSCOhost, and SpringerLink. The keywords "mobile application" and "smartphone application" were used (and also "mobile applications", "mobile apps", "mobile app", as well as "smartphone applications", "smartphone apps", and "smartphone app"). Due to a comprehensive number of articles in various journals and conference proceedings, the focus was on the eight journals listed by the Association for Information Systems (AIS) as top journals in the IS field: European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Information Systems Research (ISR), Journal of the Association for Information Systems (JAIS), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS), Journal of Strategic Information Systems (JSIS), and Management Information Systems Quarterly (MISQ)[14]. The identified articles mainly deal with mobile application marketplaces such as Apple's App Store and Google Play, mobile application privacy, and location-based services. Further topics include mobile application usability, user experience, development, and cultural differences regarding the design of mobile applications (see Table 3).

As the purpose of this study is to examine the types of access to personal information and the influence on mobile users' privacy concerns, the constructs of concern for information privacy (CFIP) (Smith et al. 1996; Stewart and Segars 2002), Internet users' information privacy concerns (IUIPC) (Malhotra et al. 2004), and mobile users' information privacy concerns (MUIPC) (Xu et al. 2012a) are described. Then, access permissions of several mobile applications for Apple iOS and Google Android are systematically reviewed and analyzed to develop the research model and generate the hypotheses.

[14] https://aisnet.org/?SeniorScholarBasket

Table 3. Overview of Mobile Application Literature in IS Research

Authors	Significant Findings	Outlet	Research Focus
Benlian et al. 2015	The construct of perceived platform openness is conceptualized and empirically validated across different smartphone platform contexts (i.e., Apple iOS and Google Android).	JIT	Marketplace
Bergvall-Kåreborn and Howcroft 2014	A qualitative study of 60 mobile application developers (Android and iPhone) based in Sweden, the United Kingdom, and the United States is analyzed around the interrelated problems of diversity, knowledge, and structure.	ISJ	Development/ Marketplace
Constantiou et al. 2014	Interviews of smartphone users and a study based on diaries show that the decision to use location-based services (LBS) is described by a comparative mode based on the value of LBS in relation to other available options, or an intuitive mode in which past experiences trigger the use of heuristics.	EJIS	Location-Based Services
Ghazawneh and Henfridsson 2015	A typology is generated that distinguished four kinds of mobile application marketplaces: closed, censored, focused, and open.	JIT	Marketplace
Hoehle and Venkatesh 2015	A survey instrument for mobile application usability is developed by adapting Apple's user experience guidelines and examining its impact on two outcomes: continued intention to use and mobile application loyalty.	MISQ	Usability
Hoehle et al. 2015	Cultural differences between the United States, Germany, China, and India are analyzed related to mobile application usability; variance is found in continued intention to use (38 percent).	EJIS	Usability/ Culture
Kehr et al. 2015	An experimental study with a mobile application that collects driving behavior data shows that a situation-specific assessment of risks and benefits fully mediates the effect of dispositional factors on information disclosure.	ISJ	Privacy
Keith et al. 2015	Two experiments are conducted (controlled simulation and real app experiment) to demonstrate the strong direct effect of mobile-computing self-efficacy on users' initial trust in location-based app vendors and their perceived risk of disclosing information.	ISJ	Privacy/ Location-Based Services
Lee and Raghu 2014	Mobile applications and their presence in the top-grossing 300 chart in Apple's App Store are tracked to find that broadening app offerings across multiple categories is a key determinant that contributes to a higher probability of survival in the top charts.	JMIS	Marketplace
Liu et al. 2014	A panel data set of 711 ranked mobile applications from Google Play is analyzed to find that the freemium strategy is positively associated with increased sales of the paid mobile apps.	JMIS	Marketplace
Oh et al. 2015	The working mechanism of one business practice that significantly influences the mobile ecosystem's generativity and platform provider's profitability via value appropriation is identified and analyzed.	JIT	Marketplace
Salo and Frank 2015	A study of 605 critical incidents (unusually positive or negative user experience) that were collected from actual mobile application users shows that users are less likely to engage in negative behaviors after negative incidents that take place outdoors or in vehicles than after indoor incidents.	ISJ	User Experience
Sutanto et al. 2013	Results of a field experiment with a mobile application show that a privacy-safe solution for delivering personalized advertising messages significantly increases both the usage of the application and the saving of adverts.	MISQ	Privacy
Xu et al. 2009	Results of a structural equation modeling show that the effect of three privacy intervention approaches (compensation, industry self-regulation, and government regulation) on an individual's privacy calculus vary based on the type of information delivery mechanism (pull and push).	JMIS	Privacy/ Location-Based Services
Xu et al. 2012b	Perceived control over personal information is found to be a key factor affecting context-specific concerns for information privacy; interaction effects are identified involving different privacy assurance approaches (individual self-protection, industry self-regulation, and government legislation).	ISR	Privacy/ Location-Based Services

3.2.2 Mobile Users' Information Privacy Concerns

The MUIPC instrument was introduced by Xu et al. (2012a), and it is based on the scale of concern for information privacy (CFIP), developed and validated by Smith et al. (1996). An empirical confirmation of the CFIP scale's reliability and validity by Stewart and Segars (2002) followed.

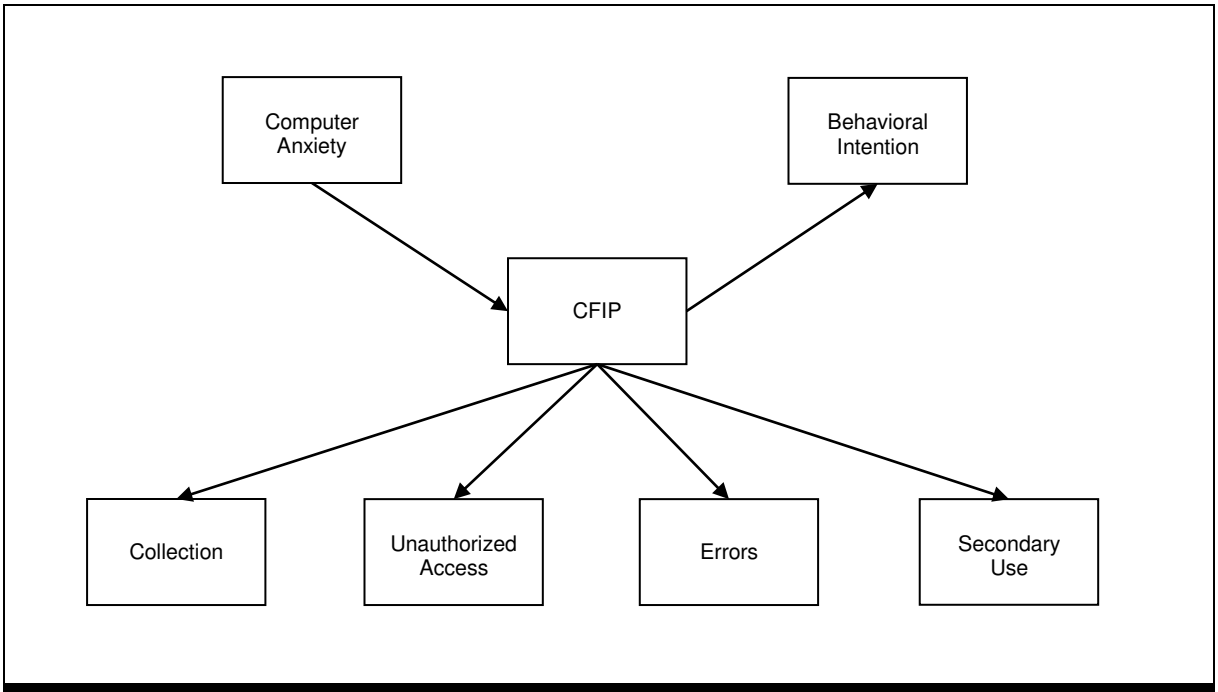

Figure 6. CFIP Model as Illustrated in Stewart and Segars 2002

The CFIP scale measures "individuals' concerns about organizational information privacy practices" (Smith et al. 1996, p. 169) with four subscales: collection, unauthorized access, errors, and secondary use. Collection describes individuals' perception that "great quantities of data regarding their personalities, background, and actions are being accumulated" (Smith et al. 1996, p. 171). The collection of personal information enables companies to use this information about individuals in relationship marketing and to target offers more accurately to individuals' interests (Culnan and Armstrong 1999). Due to unauthorized access and errors, individuals become concerned that companies should take more measures to control access to personal information and reduce errors (Smith et al. 1996). With regard to companies' poten-

tial opportunistic behaviors (Laufer and Wolfe 1977), secondary use refers to the selling or sharing of a person's information without their authorization (Smith et al. 1996).

Malhotra et al. (2004) adapted the instrument to an online environment, developing the scale of Internet Users' Information Privacy Concerns (IUIPC). IUIPC draws on the social contract and justice theories, identifying three dimensions of privacy concerns: collection of personal information (distributive justice), control over personal information (procedural justice), and awareness of organizational information privacy practices (interactional and informational justice).

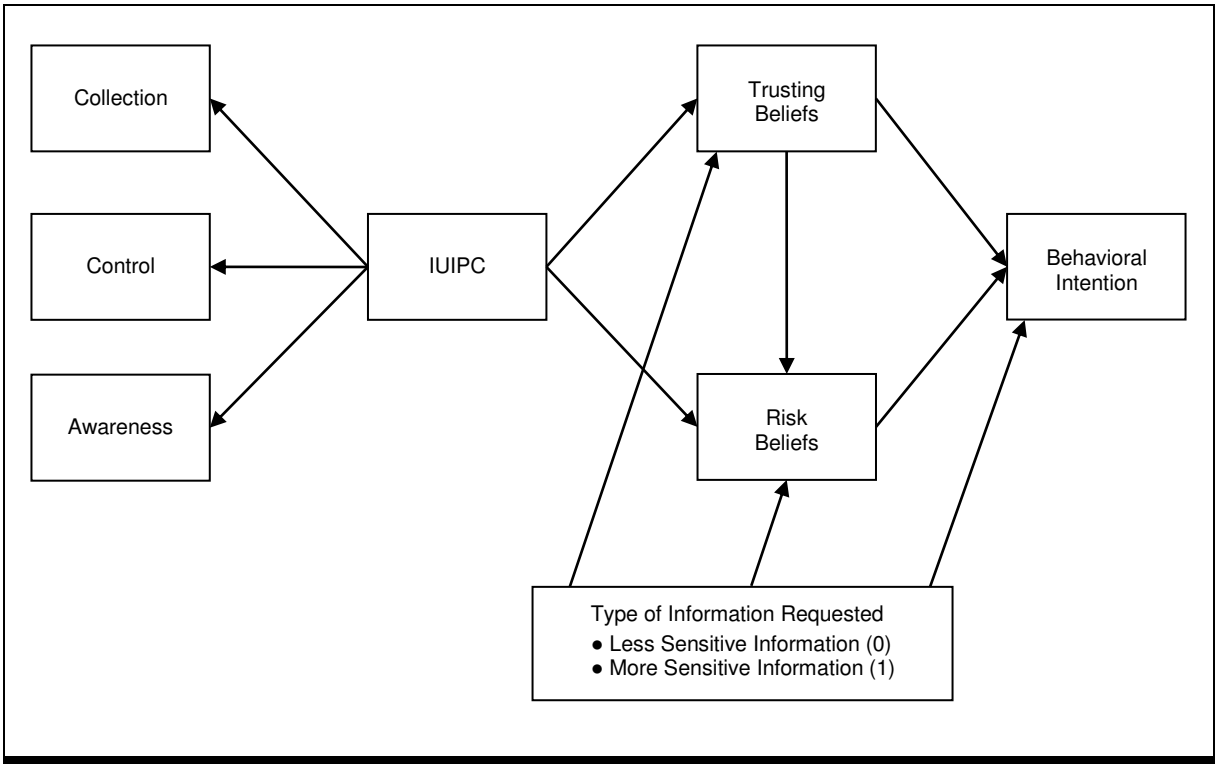

Figure 7. IUIPC Model as Illustrated in Malhotra et al. 2004

With reference to the communication privacy management theory, MUIPC theorizes privacy in the context of mobile users and presents three dimensions to measure mobile users' privacy concerns: perceived surveillance, perceived intrusion, and secondary use of personal information. Perceived surveillance expands the collection factor from CFIP and IUIPC by mobile technology capabilities for tracking and profiling mobile users (Xu et al. 2012a). Mobile devices differentiate from other IS technol-

ogies, among other characteristics, because they are equipped with environment sensors such as GPS, integrated cameras, etc. (Enck 2011). Thus, these sensors enhance mobile users' tasks, but otherwise evoke concerns about personal information. Surveillance is defined as "the watching, listening to, or recording of an individual's activities" (Solove 2006, p. 490). According to Xu et al. (2012a), perceived intrusion implies access due to CFIP dimensions unauthorized access and errors, as well as the control dimension in IUIPC. Solove (2006) defines intrusion as "invasions or incursions into one's life," which disturb "the victim's daily activities, alters her routines, destroys her solitude, and often makes her feel uncomfortable and uneasy" (p. 549). Secondary use of personal information, which is also a dimension of CFIP, is defined as "the use of data for purposes unrelated to the purposes for which the data was initially collected without the data subject's consent" (Solove 2006, p. 519). Secondary use is described as an asymmetry of knowledge, because individuals are exposed to the uncertainty that they are likely to know little or nothing about the circumstances under which their personal information is captured, sold, or processed, which creates "a sense of powerlessness and vulnerability" (Solove 2006, p. 519).

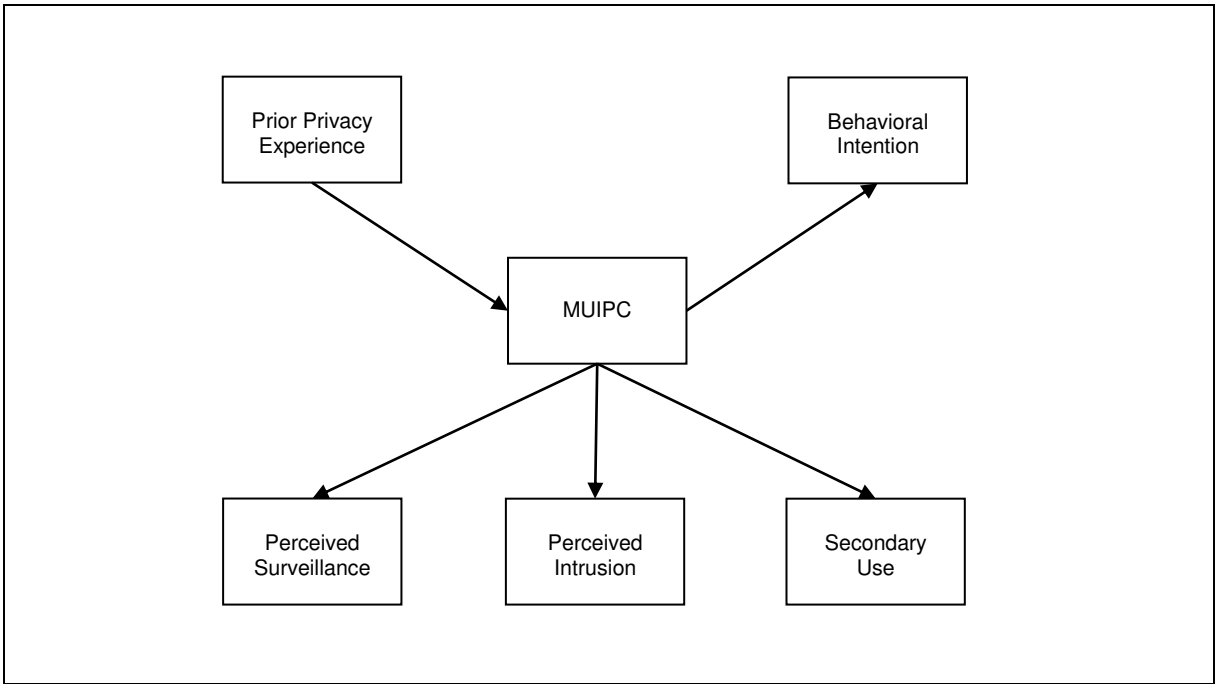

Figure 8. MUIPC Model as Illustrated in Xu et al. 2012a

3.3 Research Design and Hypothesis Generation

To gain a deeper insight into the different kind of access rights, twelve popular mobile apps were selected with an equal distribution of various categories: Facebook and Twitter (Social), Google Maps (Travel & Local), WhatsApp Messenger and Skype (Communication), Angry Birds and Fruit Ninja Free (Games), YouTube (Media & Video), Adobe Reader and Dropbox (Productivity), Google Search (Tools), and Shazam (Music & Audio). With regard to permissions, iOS asks for access to location services, contacts, calendars, reminders, photos, Bluetooth sharing, and access to the Twitter and Facebook account. For a more detailed view, the selected apps were installed and permissions were identified using a Samsung Galaxy Nexus with Android version 4.2.2 (Jelly Bean). The analysis of the twelve apps resulted in a request for 56 permissions, of which the most common 17 permissions are presented in Table 4 (six or more of the tested apps requested these permissions). The permissions are further described when tapped on, while some permissions point out that access may harm the user if the app is malicious. For example, permission to directly call phone numbers is requested, indicating that malicious apps may cost the user money by making calls without the user's confirmation. Referring to the permission to read contacts, the user is advised that malicious apps may share contact data without the user's knowledge. There are further similar permissions, e.g., relating to sending text messages, to receiving data from the Internet, or modifying system settings, which could cost the user money, cause excess data usage, or corrupt the user's system configuration.

Table 4. List of Common Mobile Application Permissions	
Categories	**Permissions**
Phone calls	Read phone status and identity
Microphone	Record audio
Your location	Approximate location (network-based)
	Precise location (GPS and network-based)
Your social information	Read your contacts
Storage	Modify or delete the contents of your USB storage
Your accounts	Add or remove accounts
	Find accounts on the device
	Use accounts on the device
Network communication	Full network access
	Receive data from Internet
	View network connections
	View Wi-Fi connections
Affects Battery	Control vibration
	Prevent phone from sleeping
Sync settings	Read sync settings
System tools	Test access to protected storage

To consider the access to personal information in a more differentiated view, access to personal information is categorized into four dimensions: personal identity, location, device content, and system and network settings. The access to identity-related information can be of concern to users, because mobile devices are considered to be "an expression of our personality" (Meschtscherjakov 2009) and contain comprehensive information about the user's identity (e.g., name, contact information, phone number, etc.). For example, the Wall Street Journal examined 101 mobile apps, of which 56 transmitted the phone's unique device ID to other companies without users' awareness or consent (Thurm and Kane 2010). Mobile users can perceive a potential misuse of information that may result in identity theft leading to the selling or sharing of their personal identity information without their authorization (Keith et al. 2012; Najjar and Bui 2012). Retrieved identity-related information can be used for unwanted solicitations, more personalized spam email and junk mail (Keith et al. 2010). Personal identity forms the first dimension of access to personal information, and it indi-

cates that mobile apps can identify the user and may send the user's profile information to other entities.

H1: *Access to personal identity has a significant positive influence on MUIPC.*

The second dimension describes access to users' location. Location-based services (LBS) have attracted considerable attention due to the potential for personalized and context-aware services (Dhar and Varshney 2011). Access to location-related information allows mobile apps to get users' approximate and precise location derived by location services using GPS or network location sources such as cell towers and Wi-Fi. LBS offer diverse benefits for personal purposes, for example, requesting driving directions to nearby gas stations, hotels, local airports, nearby attractions, or restaurants, as well as societal purposes like reducing traffic congestion, improving urban planning, arresting the spread of disease, or studying interpersonal interactions (Soper 2012). Companies like Google, Yahoo, Facebook, Foursquare, and many others use location information to provide value-added services to users (Xu et al. 2012b). However, LBS evoke mobile users' privacy concerns, because their position is tracked, or they are spammed with mobile advertising (Keith et al. 2012). Hence, the following hypothesis is proposed:

H2: *Access to location has a significant positive influence on MUIPC.*

Device content refers to information stored on mobile devices that may provide value for users in specific contexts. Allowing mobile apps to write to the storage of mobile devices implies the modification or deletion of the storage contents, which could result in unwanted intrusion. The storage often contains sensitive information such as contacts, photos, videos, calendar events, reminders, browser bookmarks and navigation history, etc. Integrated cameras are a standard feature of mobile devices, and

with the permission of the user, mobile apps are allowed to take photos and videos with the camera at any time without confirmation. For example, mobile social networking apps use the camera of mobile devices, process photos and videos, transfer private messages from one user to another, etc., which is why users' privacy is a serious challenge for app developers (Jabeur et al. 2013). Communication apps such as WhatsApp Messenger transfer sensitive text messages, and productivity apps like Dropbox have access to private files as well as sensitive company data that is stored on mobile devices. Giving mobile apps permission to read or modify calendar events and reminders also enables the apps to share or save this kind of data, regardless of confidentiality or sensitivity. Access to mobile browser's bookmarks and navigation history allows mobile apps to read all of the browser's bookmarks saved on the mobile device, as well as to read the history of all websites that the browser has visited. Thus, mobile apps can put content in a user-centered context, and process data such as user preferences, information needs, and personal time schedule (Zhang et al. 2009). Due to the confidentiality and sensitivity of mobile devices' content, the following is hypothesized:

H3: *Access to device content has a significant positive influence on MUIPC.*

The fourth dimension deals with system and network settings, which relate to configuration preferences for system components and network connections on mobile devices. System components include the configuration of several functions of the mobile device, e.g., vibration, alarm, or screen lock. With regard to network connections, the access allows mobile apps to view, change, and control network connections such as Wi-Fi connections, Near Field Communication (NFC), and Bluetooth. Mobile users benefit from networking standards like Wi-Fi, which provides fast internet connectivity, or short-range communication technologies such as NFC for services like mobile payment, or Bluetooth for data synchronization, headset applications, etc. However, access to network connections enables malicious apps to intercept and

control users' data (Leavitt 2011). Due to a potential risk of privacy intrusion through the access to system and network settings, the following is posited:

H4: *Access to system and network settings has a significant positive influence on MUIPC.*

To collect empirical data and test the proposed hypotheses, a questionnaire was created to conduct a survey with mobile app users. To increase content validity, the questionnaire was pre-tested twice. Comments and opinions on the survey questions were collected and used to revise the final questionnaire and to modify several items, especially in their wording. For the final study, participants from the USA were recruited through social networking sites, email, and mobile application forums. A total of 775 subjects participated, with 474 producing usable data (61 percent), of which 61.4 percent use Apple iOS, 34.4 percent Google Android, 2.1 percent BlackBerry OS, and 1.3 percent Windows Phone. The remaining 0.8 percent of participants were using other operating systems that were not specified (see Appendix 3 Table A1 for further demographics). The survey consisted of closed-ended questions on a five-point Likert scale. The respondents were instructed to indicate how strongly they agree or disagree with a number of statements relating to their privacy concerns when using mobile apps and their feelings concerning the intrusion if mobile apps are able to access to different information (see Appendix 3 for the survey instrument).

3.4 Data Analysis and Results

Since the construct of access to personal information was developed based on a systematic review and analysis of several mobile apps' access permissions, a proper factor structure of the construct was established in the first instance. Due to the large number of indicators, an exploratory factor analysis (EFA) was conducted as a dimensional reduction method using the principal component analysis (PCA) with varimax rotation as the extraction method. The total number of items was reduced

based on four constructs: personal identity, location, device content, and system and network settings, with a total of 25 indicators (see Appendix 3 Table A2). Structural equation modeling (SEM) was conducted to test the hypothesized relationships. All indicators were modeled as being reflective of their respective constructs and MUIPC was conceptualized as a second-order construct with three first-order dimensions: perceived surveillance, perceived intrusion, and secondary use. The loadings and cross loadings of the constructs indicate a good model fit (see Appendix 3 Table 2 and Table A2). The analysis of Cronbach's alpha ranging from 0.81 to 0.95 and composite reliability (CR) ranging from 0.89 to 0.96 support the internal consistency of the scales, and the average variance extracted (AVE) ranging from 0.61 to 0.88 indicate convergent and discriminant validity.

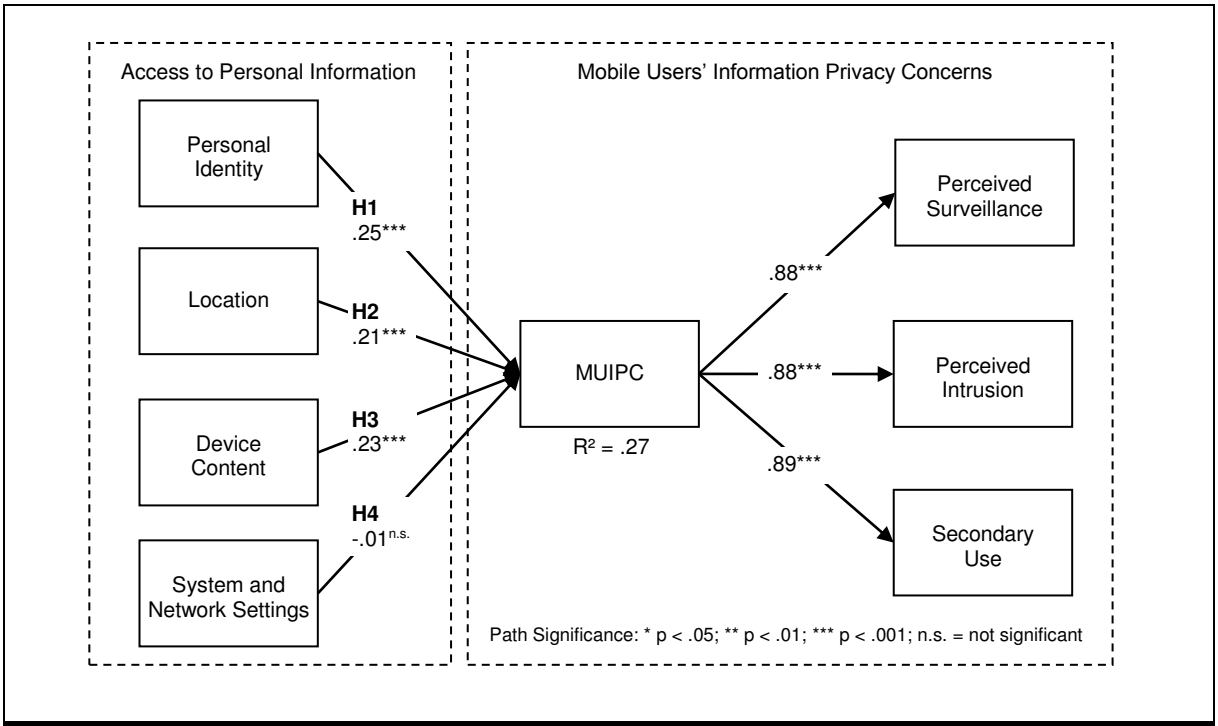

Figure 9. Results of Structural Equation Modeling

The results of the structural equation modeling show that of the four hypotheses, all but one involving the influence of system and network settings were found to be significant. Consistent with H1, personal identity has a significant positive effect on MUIPC (β = 0.25, t = 5.59). Similarly, H2 and H3 are supported as both location (β = 0.21, t = 4.02) and device content (β = 0.23, t = 4.13) have significant positive effects

on MUIPC. Regarding the R^2 of MUIPC, the constructs of access to personal information explain 27 percent of the overall variance of the MUIPC construct.

3.5 Discussion of Findings and Implications

Due to the significant path coefficients of the influence of access to personal identity, location, and device content on MUIPC, a deeper examination of these three dimensions is recommended. To respond to the call for research investigating antecedents and consequences of information privacy concerns (Smith et al. 1996; Stewart and Segars 2002), in the mobile context, the construct of access to personal information should be considered along with further constructs such as prior privacy experience (Smith et al. 1996; Xu et al. 2012a), computer anxiety (Stewart and Segars 2002), and control over personal information (Malhotra et al. 2004; Xu et al. 2012b). Thus, a comprehension of mobile users' privacy concerns can be further enhanced. Further research can also consider potential distinctions between free and paid apps, which can have an influence on users' privacy concerns. From a practical perspective, the results indicate that app providers should recognize access to personal information as a significant indicator affecting MUIPC. Understanding mobile users' privacy concerns can help app providers to better address drawbacks resulting from those concerns. App providers should ensure that they access personal information stored on mobile devices only if necessary and justified with value-added services. For example, location should only be tracked if the mobile app requires this function to work properly, such as with the navigation system of the Google Maps mobile app. In this context, trust is a key aspect to enhance users' belief to which degree "a firm is dependable in protecting consumers' personal information" (Malhotra et al. 2004, p. 341). Several studies in the field of electronic commerce have found trust to have a significant impact on information sharing and purchase decisions (e.g., Dinev and Hart 2006; Gefen et al. 2003; McKnight et al. 2002). Within the frame of mobile apps, trust can lead users to allow access to personal information and conduct transactions such as pay-per-download, in-app purchase, or subscriptions. A trust-based relation-

ship between app providers and users can help to build user confidence and overcome privacy concerns. Thus, app users can expect safe environments in which app providers act in a regular, honest, and cooperative way. With regard to creating a trust-based relationship, several studies have identified various methods, of which different privacy assurance approaches have been in the focus of mobile application research (e.g., Keith et al. 2010; Xu et al. 2009).

Three privacy assurance approaches are distinguished: individual self-protection, industry self-regulation, and government regulation (Xu et al. 2012b), all of which have a direct negative influence on privacy concerns. That implies that privacy assurances offered by app providers can alleviate mobile users' privacy concerns. The individual self-protection approach allows users to control the access to personal information, for example by turning off the location tracking from their mobile devices. In contrast to Google Android, Apple iOS users can turn off access in the privacy settings if supported by the mobile app. Taking this into account, app providers should offer users the opportunity to turn off access to their personal information and advise users that certain functions of a mobile app may not work when doing so, e.g., the navigation system of the Google Maps mobile app will not work if location tracking is turned off. Further individual self-protection approaches comprise the users' refusal to provide personal information, misrepresentation of personal information, removal of personal information, negative word-of-mouth communication to others, complaining directly to online companies, and complaining indirectly to third-party privacy organizations (Son and Kim 2008). For example, app users may refuse to provide personal information by abbreviating the names of their contacts if the mobile app has access to the contacts stored on the users' mobile devices. This can prevent app providers from linking users' contacts to information stored on the providers' databases. The industry self-regulation approach "places the responsibility for protecting information privacy in the hands of those that gather, use, and sell personal information" (Xu et al. 2009, p. 143). App providers can use privacy seals, guarantees,

and promises such as privacy policies, which positively influence trusting beliefs (Keith et al. 2010). For example, TRUSTe offers a privacy seal program specifically for mobile app developers (TRUSTe 2013). App providers should take privacy seals into account and communicate privacy policies to their users, with the result that users can understand why their personal identity, location, and device content is accessed by the mobile app. The government regulation approach "relies on the judicial and legislative branches of a government agency for protecting personal information" (Xu et al. 2009, p. 143). This approach entails that users are protected from misuse and breach of privacy laws, which can lead offenders to be punished by law, establishing and maintaining a deterrent effect (Xu et al. 2012b). For example, the California Department of Justice introduced a privacy law as of October 30, 2012, and requested app developers to "post a privacy policy within their app that informs users of what personally identifiable information about them is being collected and what will be done with that private information" (California Department of Justice 2012). The implementation of privacy policies is even more important considering both industry self-regulation and government regulation. Due to the alleviating effect of privacy assurance approaches on privacy concerns, app providers should consider these approaches, i.e., individual self-protection, industry self-regulation, and government regulation, in particular when accessing users' personal identity, location, and device content.

3.6 Limitations and Future Research

One limitation of this research is found in the fact that most of the participants were up to 30 years old, with the majority being younger than 20 years old (see Appendix 3 Table A1). Although the participants fall in the target users for mobile apps, care must be taken in any effort to generalize the findings beyond the boundaries of the sample. Future researchers should repeat this study with a more diverse sample for enhanced generalizability and further analyses are required to exclude possible confounded impacts of those demographic characteristics on the constructs of this re-

search. In terms of generalizability, another bias possibility is self-selection among the survey respondents due to several reasons. One reason is that data were collected through an online survey, which is liable to a self-selection bias (Kim et al. 2002). A monetary reward in the form of two $25 Amazon vouchers was offered. This could have drawn participants who were more prone to monetary incentives, leading to a sampling bias (Hui et al. 2007). Another reason for self-selection bias is that in the postings and emails the topic of the survey was mentioned (mobile app privacy). Mobile app users who are more concerned about information privacy might also be those who are more likely to respond to the survey (Kankanhalli et al. 2005). A further limitation is that the study was conducted with participants from the United States, which has a strong reputation in this research context. Future research should be conducted in other countries to provide further insights into the effects of access to personal information and privacy concerns. An international context can be integrated by analyzing cultural differences regarding the evaluation of access to personal information and the impact on mobile users' information privacy concerns.

With regard to the types of information requested by mobile apps, future research should also investigate interaction effects, because in most cases multiple access permissions are requested at the same time. Hence, individual effects are less likely to be informative than interaction effects (Xu et al. 2012b). As this study has shown that the access to personal identity, location, and device content is significantly influencing mobile users' information privacy concerns, a further segmentation of the types of access to personal information is recommended to analyze interaction effects for a differentiated approach. According to the results of the survey of this study, the participants were mostly concerned with the following mobile application permissions. In Table 5, mobile application permissions are listed with mean values above the threshold of four (1 = low privacy concerns, 5 = high privacy concerns).

Table 5. Mean Values for Privacy Concerns with Mobile Application Permissions		
Permission	**Mean Value**	**Standard Deviation**
Access to text messages	4.28	1.04
Access to precise location	4.25	0.92
Access to send text messages	4.24	1.05
Access to contacts	4.19	0.95
Access to accounts	4.16	1.01
Access to social media accounts	4.16	1.00
Access to photos	4.13	1.06
Access to call logs	4.10	1.07
Access to videos	4.03	1.12

Upon these findings, the following clustering of mobile application permissions is suggested: access to identity, location, contacts, photos/videos, and text messages. The constructs of identity and location are taken from the study of Degirmenci et al. (2013), while device content is further divided into contacts, photos/videos, and text messages. Table 6 shows the access rights of the permissions in more detail.

Table 6. Access Rights of Proposed Mobile Application Permissions	
Permission	**Access Rights**
Identity	Access name and profile data
	Find accounts on device (such as email, WhatsApp, Facebook, Twitter)
	Add or remove accounts
Location	Approximate location (network-based)
	Precise location (GPS and network-based)
	GPS access
Contacts	Read contacts
	Modify or delete contacts
	Create contacts
Photos/Videos	Access photos and videos
	Modify photos and videos
	Delete photos and videos
Text messages	Read text messages
	Modify or delete text messages
	Create and send text messages

In order to measure interaction effects of the five proposed mobile application permissions, a 2 (with/without identity) × 2 (with/without location) × 2 (with/without contacts) × 2 (with/without photos/videos) × 2 (with/without text messages) between-

subject, full-factorial experimental design is suggested. The following theoretical model is recommended for future research (see Figure 10).

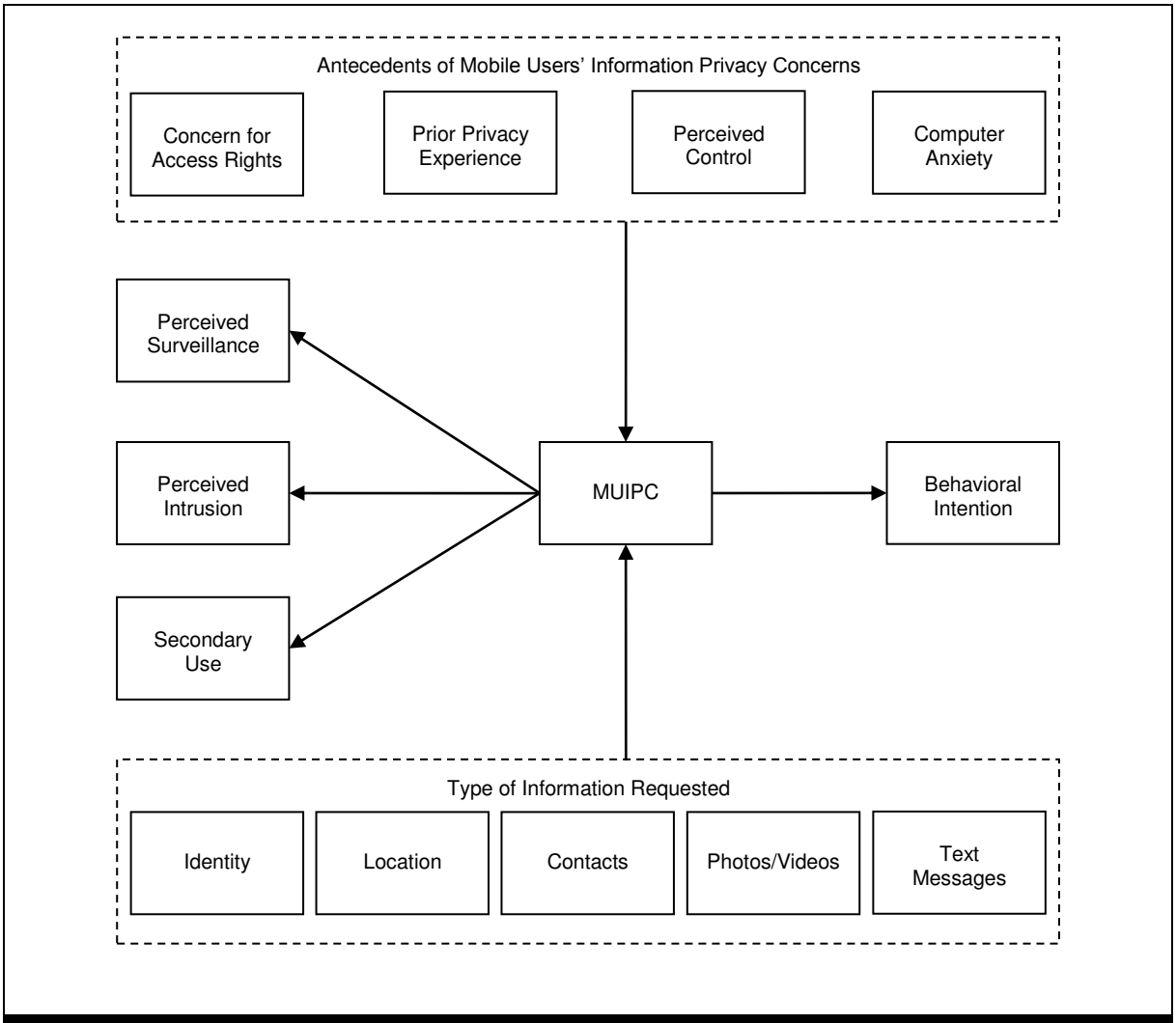

Figure 10. Theoretical Model for Future Research

The core construct of the proposed model is based on the MUIPC model adapted from Xu et al. (2012a) as a second-order factor model with three dimensions: secondary use, perceived surveillance, and perceived intrusion (see Figure 8 for the original model). With regard to the antecedents of mobile users' information privacy concerns, the construct of prior privacy experience has been adapted from Xu et al. (2012a) for the proposed model, perceived control refers to the study from Xu et al. (2012b), and computer anxiety has been drawn from Malhotra et al. (2004). Concern for access rights is a self-developed new construct, which is assumed to also have a significant impact on MUIPC, specifically in a mobile application privacy concern con-

text. Referring to the IUIPC model as illustrated in Malhotra et al. (2004) (see Figure 7 for the original model), it is further assumed that the type of information requested will significantly influence users' perceptions. In a mobile application context, the types of information requested by mobile applications—access to identity, location, contacts, photos/videos, and text messages—are assumed to affect mobile users' privacy concerns. As shown by several studies (Malhotra et al. 2004; Smith et al. 1996; Stewart and Segars 2002; Xu et al. 2012a), privacy concerns will have a significant impact on the behavioral intention to disclose personal information.

4. Energy Reduction of Electric Vehicles through Mobile Applications

This chapter refers to the article “How Can Mobile Applications Reduce Energy Consumption? An Experimental Investigation of Electric Vehicles” (see Appendix 4). The paper was presented by the author of this doctoral thesis at the 23rd European Conference on Information Systems (ECIS) in Münster, Germany (May 26-29, 2015). ECIS is affiliated with the Association for Information Systems (AIS) and it is considered “the premier Information Systems event in the European and Middle East region and provides a platform for panel discussions and the presentation of peer-reviewed academic research.”[15] The paper was presented at the track “Sustainably Digital” and it was published in the conference proceedings. This research study has been developed within the frame of the project “Showcase Electric Mobility”, which was funded by the German Federal Ministry for Economic Affairs and Energy under grant no. 16SNI011B. The project was a cooperation between industry partner Volkswagen AG and university partners Braunschweig University of Technology, University of Hannover, Ostfalia University of Applied Sciences, and Clausthal University of Technology, as well as the Automotive Research Center Niedersachsen.

4.1 Introduction

In IS research, the role of information systems (IS) for environmental sustainability has received considerable attention over the last several years (Elliot 2011; Hilpert et al. 2013; Ijab et al. 2012; Malhotra et al. 2013; Melville 2010; Watson et al. 2010). In view of global warming and climate change, a transition from combustion to electric vehicles (EVs) can help reduce greenhouse gas (GHG) emissions. According to Watson et al. (2012), sustainable behavior often lacks relevant information about its environmental effects, which is why there is a need to “develop information systems

[15] https://www.wi.uni-muenster.de/events/activities

that provide individuals with accurate, meaningful, and actionable information about the environmental impact of personal decisions" (p. 30). One such information system is the driver assistance system that provides relevant information to improve driving behavior, e.g., by means of adaptive cruise control, forward collision warning, driver drowsiness detection, traffic sign recognition, parking assistance, night vision, etc. (Akhlaq et al. 2012).

This study investigates the impact of smartphone-based driver assistance systems on the energy consumption of EVs. Watson et al. (2010) called for research to analyze which information consumers need to increase their energy efficiency and to reduce CO_2 emissions in order to contribute to the new IS subfield of energy informatics. In this study, the focus is on smartphone-based driver assistance systems as a source of information, helping to improve driving behavior and reduce energy consumption. This approach attempts to offer recommendations for automotive manufacturers to better address the challenge of reducing energy consumption and thus CO_2 emissions. A smartphone-based driver assistance system is chosen with the potential to influence the energy consumption of EVs. An experimental design is developed by defining a control group and a treatment group, with the smartphone-based driver assistance system being determined as the treatment in order to measure the influence on the energy consumption. A null hypothesis and an alternative hypothesis is generated to test the experimental design regarding differences in the energy consumption of the groups. This study makes a theoretical contribution by conceptualizing that the energy consumption of EVs is significantly influenced by smartphone-based driver assistance systems. The following research question is proposed:

RQ: *What impact do smartphone-based driver assistance systems have on the energy consumption of electric vehicles?*

4.2 Theoretical Background and Foundations

4.2.1 Electric Vehicles and Environmental Sustainability

The overall challenge of IS research on environmental sustainability is to mitigate global warming and thus climate change (Aoun et al. 2011; vom Brocke et al. 2013; Watson et al. 2010), which is mainly caused by GHG emissions (Intergovernmental Panel on Climate Change 2008, p. 39; National Academy of Sciences 2005). Approximately 25 percent of worldwide CO_2 emissions, which are an important ingredient of GHGs and contribute to global warming, are attributable to transport and nearly three-quarters of these are generated by road transport (International Energy Agency 2009, p. 3). EVs are considered to have the potential to reduce CO_2 emissions substantially, given that electricity is produced from renewable energy sources (see Figure 11).

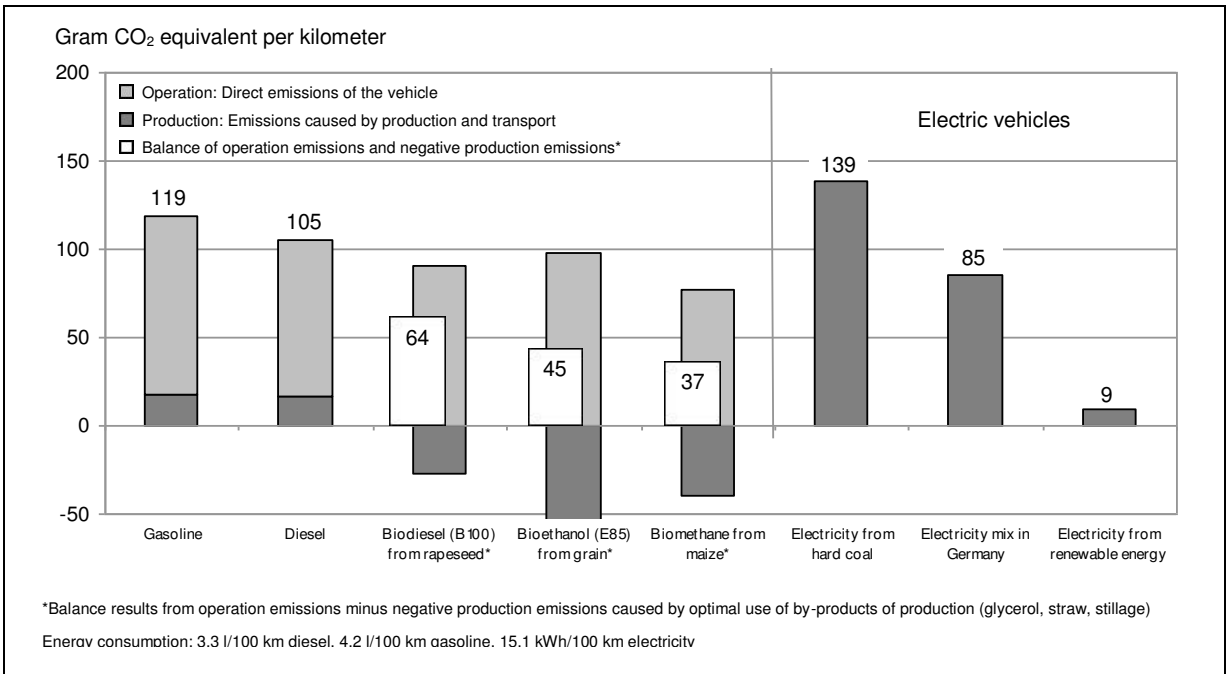

Figure 11. Comparison of Emissions (Hohenberger and Mühlenhoff 2014, p. 40)

The main factors which impede the acceptance of EVs are high acquisition costs and short driving ranges due to insufficient battery technologies (Flath et al. 2012; Busse et al. 2013; Wagner et al. 2013b). Reducing the energy consumption of EVs implies both ecological and economic benefits: it contributes to lowering CO_2 emissions, and

it increases range. Moreover, electricity costs can be saved and vehicle wear can be reduced. Regarding McKinsey's EV index that assesses a nation's readiness to support an EV industry based on supply and demand, as of January 2012, the leading countries in the field of electric mobility in descending order are Japan, the United States, France, Germany, and China (Krieger et al. 2012). Among automotive manufacturers, there is a competition to lower operating costs and lower CO_2 emissions. The global market for EVs is expected to grow from 137,950 vehicles in 2012 to 1.75 million in 2020 (Hurst and Gartner 2012).

4.2.2 Environmental Sustainability in Information Systems Research

To give an overview of the current research on information systems for environmental sustainability, a literature review was conducted on six major IS research databases: ACM, AISeL, IEEE, Science Direct, EBSCOhost, and SpringerLink. The keywords "environmental", "sustainability", "Green IS", and "Green Information Systems" were used. The literature was searched according to the guidelines by Webster and Watson (2002) and vom Brocke et al. (2009). Due to a comprehensive number of articles in various journals and conference proceedings, the focus was on the eight journals listed by the Association for Information Systems (AIS) as top journals in the IS field[16]. The identified articles were found in the Journal of the Association for Information Systems (JAIS), in a Special Issue ("The Greening of IT") of the Journal of Strategic Information Systems (JSIS), in the Issues and Opinions as well as the Theory and Review section of the Management Information Systems Quarterly (MISQ), and in a Special Issue of MISQ ("IS & Environmental Sustainability"). The identified articles cover topics in the area of conceptual frameworks for IS and environmental sustainability, sustainable behavior research, organizational IS, mobile IS, and IS for transportation systems (see Table 7).

[16] https://aisnet.org/?SeniorScholarBasket

Table 7. Overview of IS Literature Regarding Environmental Sustainability

Authors	Significant Findings	Outlet	Research Focus
Butler 2011	Senior managers and practitioners are interviewed for an explanatory case study design in order to explore the enabling effects of IS to help manage environmental compliance and related organizational risks; four propositions on Green IS are presented.	JSIS	Organizational
Corbett 2013	Results from three organizational case studies suggest that carbon management systems (CMS) can be effective at changing employees' environmental behaviors; four propositions for further Green IS research are developed.	JAIS	Organizational/ Behavior
Elliot 2011	A review of environmental sustainability literature is conducted to develop a framework for IT-enabled business transformation.	MISQ	Framework/ Organizational
Loock et al. 2013	Results of a field experiment suggest that the implementation of Green IS in electricity customers' private households should include goal-setting functionalities; default goals indirectly affect energy consumption behavior by affecting goal choice, and feedback on energy consumption influences goal adjustment.	MISQ	Behavior
Marett et al. 2013	A survey with active company truck drivers and owner operators shows that economic benefits and industry pressures positively influence drivers' use of bypass systems, but the environmental benefits of the technology do not.	MISQ	Behavior
Melville 2010	The belief-action-outcome (BAO) framework is developed and ten research questions are discussed based on a literature review of environmental sustainability articles.	MISQ	Framework
Pitt et al. 2011	A research agenda is identified to pursue studying the use of smartphones in search of a sustainable information technology agenda.	JSIS	Mobile/ Organizational
Seidel et al. 2013	Interviews with personnel involved in an organization's sustainability initiative are conducted to develop a framework of four functional affordances for business transformation: reflective disclosure, information democratization, output management, and delocalization; nineteen research questions are discussed.	MISQ	Framework/ Organizational
Watson et al. 2010	The energy informatics framework is developed and nine research questions are discussed related to interactions between relevant stakeholders (suppliers, consumers, and governments) and the energy system's elements (flow networks, sensor networks, and sensitized objects).	MISQ	Framework
Watson et al. 2011	Four transportation systems (Vélib, Zipcar, ERP Singapore, and Transantiago) that attempt to reduce carbon emissions are analyzed in terms of four innovation drives: ubiquity, uniqueness, unison, and universality.	JSIS	Transportation

In order to further focus on IS literature specifically dealing with EVs, articles were found in the following AIS conferences: Americas Conference on Information Systems (AMCIS), European Conference on Information Systems (ECIS), and the International Conference on Information Systems (ICIS). The main focus of the identified articles is on EV charging. Further articles focus on behavior, business models, mobile systems, and culture.

Table 8. Overview of IS Literature Regarding Electric Vehicles

Authors	Significant Findings	Outlet	Research Focus
Brandt et al. 2013	An analysis of synergy effects of information systems on residential photovoltaic panels and electric vehicle charging shows that households can decrease annual net energy costs by up to 68 percent.	ICIS	Charging
Busse et al. 2013	Results of a structural equation modeling show that there exist major differences in adoption behavior of eco-innovations between Germans and Chinese; primary sources' influence is found to be the most important predictor of the intention to adopt electric vehicles.	ICIS	Behavior/ Culture
Dauer and Flath 2015	A simulation model is developed to explore requirements for battery switch stations (research-in-progress paper).	ECIS	Charging
Degirmenci et al. 2015	Test drives with an electric vehicle show that using smartphone-based driver assistance systems significantly reduces the energy consumption of electric vehicles.	ECIS	Mobile/ Behavior
Flath et al. 2012	Solution concepts are developed on decision support systems for electric vehicle charging by using simulations based on empirical driving data and electricity price data.	AMCIS	Charging
Kahlen et al. 2014	An IT-enabled business model is presented where fleet owners charge electric vehicles during off peak hours and sell energy back to the grid during peak hours, thereby reducing the average electricity price by 3.2 percent and carbon dioxide emissions by 2.4 percent.	ECIS	Business Model
Nastjuk and Kolbe 2015	A survey of 341 participants shows that through the provision of supportive IS in electric vehicles, individuals perceive less range stress.	ICIS	Behavior
Schmidt and Busse 2013	The effects of electric vehicle charging on existing power plant capacities in Germany are investigated.	AMCIS	Charging
Wacker et al. 2014	By means of a cluster analysis from a survey in China, four different user groups for electric vehicles are identified: conservative technology users, environmentally unconscious consumers, high-tech enthusiasts, and technophobic environmentalists.	ICIS	Behavior
Wagner et al. 2013a	An IT-enabled business model is presented to use electric vehicles as distributed storage devices to balance the grid; results of computational simulations show that this solution is able to support power grid stability while generating revenues for the operating intermediary.	ECIS	Business Model
Wagner et al. 2013b	A point-of-interest-based business intelligence system for city planners is presented to determine the optimal locations for electric vehicle charging stations; more than 32,000 charging sessions are analyzed by means of a case study for Amsterdam and Brussels.	ICIS	Charging
Wagner et al. 2014	Using information on charge point usage of 273 charge points with 427 individual outlets within the city of Amsterdam, a decision support system is developed to determine the optimal locations for charge points.	ECIS	Charging

4.3 Research Design and Hypothesis Generation

A field experiment was conducted, in which the presence and absence of a mobile app was manipulated that served as a smartphone-based driver assistance system. In order to measure the energy consumption, test drives were arranged with an all-electric, lithium-ion battery powered, small passenger city car. The test drives were performed from June 26, 2014 to August 12, 2014 with 39 participants (see Appendix 4 Table A1 for demographics). In order to increase external validity (Bordens and Abbott 2002), the participants were randomly assigned to the control and experi-

mental group. To minimize confounding effects, and hence increase internal validity (Shadish et al. 2002), extraneous conditions were controlled by using the same car and the same predetermined route for each test drive. For reasons of regional proximity, the test drives were performed in the city of Hanover, Lower Saxony, Germany. The route is a mix of city traffic and high-speed traffic, which allows real-life conditions for the test vehicle in the city car class. Endogenous conditions concerning driving mode and auxiliary equipment parameters, such as the in-vehicle infotainment and the air conditioning system, were equally set in order to ensure similar conditions for the test drives. Exogenous conditions regarding traffic, weather, etc. were controlled by conducting all test drives on the same predetermined route to ensure similar traffic conditions, and in a time period of about seven weeks to provide similar weather conditions. Minor variances of exogenous conditions regarding traffic and weather cannot completely be ruled out, which is implicated by real-life conditions in field experiments. The length of the route was approximately 13.8 km, and the duration was around 30 minutes. For the treatment of the experiment in order to monitor excessive acceleration and hard braking, the mobile app “Smooth Driver” was chosen due to its accurate, practical, and relevant usability as well as the motivational aspect to drive more energy-efficiently by giving the task to drive without dropping a ball out of a visualized bowl. It was due to this task-oriented aspect with the goal to drive energy-efficiently, which is why “Smooth Driver” was found to be appropriate for the experiment.

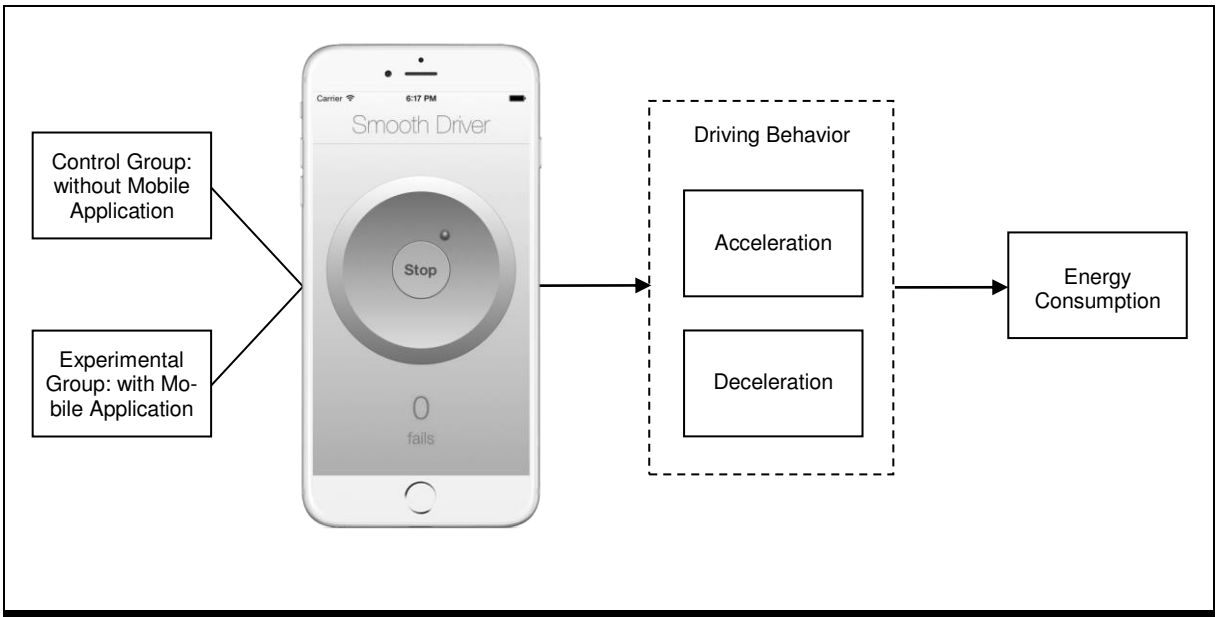

Figure 12. Experimental Setting

The participants of the test drives were briefly introduced to the test vehicle and were told to drive as they normally would. They did not know that the energy consumption of the test drives were in focus of the study and they were not informed whether they were assigned to the control group or the experimental group. In the case of the experimental group, the mobile app was deployed during the test drives using an iPhone 5 with iOS 7.1.1 attached to a mount in the car. The app displayed a digital red ball, which rested in the middle of a grey bowl in its idle position. An abrupt change in velocity or direction moved the ball out of the bowl, sending a sound signal to the driver and resulting in an increase of the fail-counter at the bottom of the app. The goal was to drive without dropping the ball out of the bowl, encouraging the participants to drive more gently and thus more energy-efficiently. Prior to the test drives, seven rehearsal drives were performed in order to pretest the applicability of the EV, the predetermined route, and the mobile app.

On the basis of the experimental design, the following null hypothesis and according alternative hypothesis is proposed:

H0: *Using smartphone-based driver assistance systems does not significantly reduce the energy consumption of electric vehicles.*

H1: *Using smartphone-based driver assistance systems significantly reduces the energy consumption of electric vehicles.*

4.4 Data Analysis and Results

The statistical test of the null hypothesis was evaluated by examining the significance criterion (α), the precision of sample estimates, and the effect size (Baroudi and Orlikowski 1989). For the significance criterion, a t-test was conducted (Dennis and Valacich 2001; Hair et al. 2006) and the statistical approach was formulated as follows:

$$t = \frac{\bar{x}_A - \bar{x}_B}{\hat{\sigma}_{\bar{x}_A - \bar{x}_B}} \tag{3}$$

$$\hat{\sigma}_{\bar{x}_A - \bar{x}_B} = \sqrt{\frac{(n_A - 1) \cdot \hat{\sigma}^2{}_A + (n_B - 1) \cdot \hat{\sigma}^2{}_B}{(n_A - 1) + (n_B - 1)} \left(\frac{1}{n_A} + \frac{1}{n_B} \right)} \tag{4}$$

$$\hat{\sigma}^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n - 1} \tag{5}$$

$$df = n_A - 1 + n_B - 1 \tag{6}$$

$$H_0 : \mu_A = \mu_B \tag{7}$$

where $\bar{x}$ is the mean value of the energy consumption in kWh/100 km, *A* is the control group and *B* is the experimental group, $\hat{\sigma}$ is the standard deviation of the mean, $\hat{\sigma}^2$ is the estimated variance, df is the number of degrees of freedom, and μ is the expected value.

Six of the 39 test drives were identified as outliers (noise), which were excluded from the calculations due to a possible bias induced by the experiment and a significant impact on the statistics (Cousineau and Chartier 2010). The t-test with 31 degrees of freedom produced a t-value of 3.25 at a significance level of $p < 0.01$ (two-tailed). The t-test was computed on the basis of the observed values of the energy consumption in kWh/100 km of the control group and the experimental group (see Appendix 4 Table A2 for a full list of the observed values of each participant, as well as the mean values, estimated variances, and standard deviations of the groups).

Measuring the effect size of empirical observations is considered a supplement to the null hypothesis significance test, and it also determines the practical significance of results (Kirk 1996). To measure the effect size, the following is posited:

$$d = \frac{\bar{x}_A - \bar{x}_B}{\hat{\sigma}_{AB}} \tag{8}$$

$$\hat{\sigma}_{AB} = \sqrt{\frac{(n_A - 1) \cdot \hat{\sigma}^2{}_A + (n_B - 1) \cdot \hat{\sigma}^2{}_B}{(n_A - 1) + (n_B - 1)}} \tag{9}$$

where d is the effect size according to Cohen's *d* (Cohen 1988), and $\hat{\sigma}_{AB}$ is the pooled standard deviation estimate (Hedges 1981). The examination of the effect size returned a result of $d = 1.15$. Referring to Cohen (1988), $d = 0.2$ is a small effect, $d = 0.5$ is a medium effect, and $d = 0.8$ is a large effect. For $d = 1.15$, $n = 33$, and $\alpha = 0.01$, the power was 0.97 ($1 - \beta$), exceeding the recommended value of 0.80 for power (Cohen 1992).

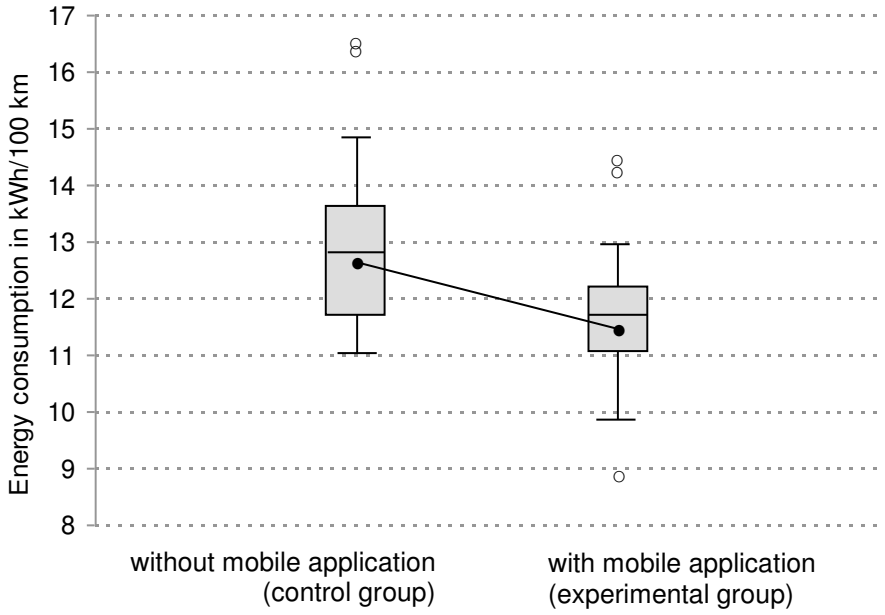

Figure 13. Boxplot for the Results of the Experiment

The results of the test drives are summarized in a boxplot in Figure 13. The boxplot shows the minimum, first quartile (Q1), median, third quartile (Q3), and the maximum of the energy consumption for the control group and the experimental group. ● represents the mean, and ○ represents outliers, which are 1.5-times of the interquartile range (Q3 – Q1) away from the box (Bordens and Abbott 2002; Hair et al. 2006). The two medians do not overlap, indicating that the differences between the medians of the control group and experimental group are statistically significant at a 95 percent confidence level (McGill et al. 1978; Mullenex 1990). Through the deployment of the mobile application, the average energy consumption decreases from 12.6 kWh/100 km to 11.4 kWh/100 km, which implies an energy reduction by 9.5 percent.

4.5 Discussion of Findings and Implications

The results of the statistical tests show that differences in the energy consumption of the control group and experimental group are statistically significant ($t = 3.25$, $p < 0.01$) and exhibit a large effect size ($d = 1.15$, power = 0.97). Thus, there is evidence

supporting the hypothesis that using smartphone-based driver assistance systems significantly reduces the energy consumption of EVs. The null hypothesis is rejected. Besides energy consumption, during the test drives, average speed, maximum speed, acceleration, deceleration, and driving time were also tracked. In Figure 14, the mean values of the experimental group are compared to the control group, where the scale of the control group is set to 100 percent. This comparison shows that energy-efficient driving does not necessarily involve a delay in the time of arrival. Energy consumption, average speed, maximum speed, acceleration, and deceleration are lower in the experimental group. A view on the bars in the line “driving time” illustrates that there is no major difference between the control group and the experimental group. With regard to the defined parameters of the test drives, this implies that both groups required a similar average time for the test route, although the experimental group consumed less energy.

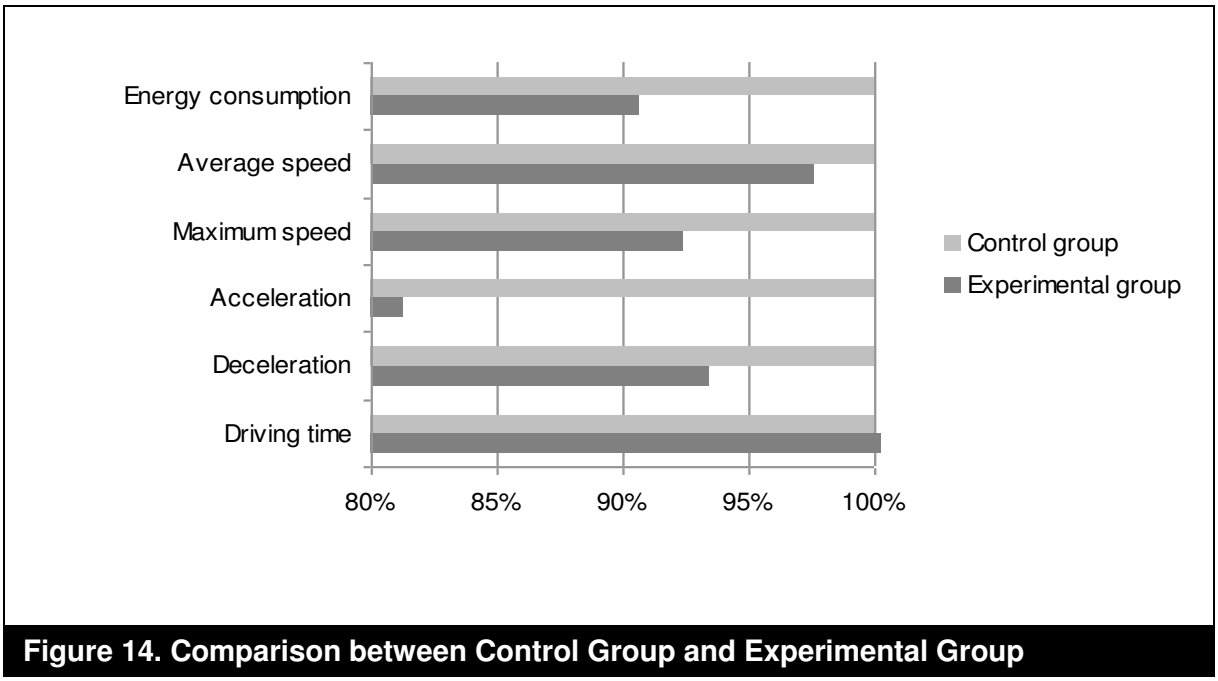

Figure 14. Comparison between Control Group and Experimental Group

Due to the statistical and practical significance of the hypothesis testing of the influence of mobile apps on energy reduction, this phenomenon should be deeper examined. First, in the experimental investigation, a mobile app was employed that gives information on excessive acceleration and hard braking to the driver. Further research is recommended to explore for advanced conditions to influence acceleration

and braking for energy-efficient driving, and moreover to consider additional functions that have the potential to improve driving behavior and consequently reduce energy consumption. In the context of EV driving, besides acceleration and braking, additional functions could refer to the energy recuperation system of a vehicle and to the auxiliary equipment such as the in-vehicle infotainment system and the air conditioning system of a vehicle. As a result, additional energy might be saved through efficient utilization of these systems, influenced by relevant information provided by mobile apps to support sustainable behavior. Further research should conduct appropriate experiments in order to investigate these hypothesized relationships. In this regard, an integration of smartphones in the car, e.g., phone-centric car connectivity solutions like Apple's CarPlay, Android Auto and MirrorLink, could be examined. Second, the main focus of this study was on the energy consumption of electric vehicles. Further research could investigate interdependencies of velocity, acceleration, and energy consumption considering an influence of mobile apps on the driving behavior. Third, the adoption of driver assistance systems for EVs should be analyzed. An adoption is crucial for a successful implementation. In order to analyze the adoption, automotive manufacturers could be interviewed and potential users could be surveyed. Thus, influencing factors of the adoption would be identified and new insights would be provided to the field. In this context, further research could also investigate the day-to-day practicability of smartphone-based driver assistance systems for energy-efficient driving. Mobile apps such as "Smooth Driver" could be appropriate for training individuals to drive more energy-efficiently and therefore could have a long-term effect on the driving behavior. For this reason, further experiments could be conducted to test this causal relationship.

The results of this study provide practical implications for automotive manufacturers to better address the challenge of reducing energy consumption and thus CO_2 emissions. Providing EV drivers with accurate, meaningful, and actionable information about the environmental impact of the driving behavior can lead to a reduction of the

energy consumption. The findings show that smartphone-based driver assistance systems can offer such information. Automotive manufacturers compete to lower operating costs and lower CO_2 emissions, and a transition from combustion to EVs can help automotive manufacturers to achieve these goals. Nevertheless, there exists a critical perspective on a transition. For example, in the United States a transition from combustion to EVs could increase CO_2 emissions, because half of the electricity is produced from coal (Hasan and Dwyer 2010). Against this backdrop, for a substantial reduction of CO_2 emissions, electricity needs to be produced from renewable energy sources. Automotive manufacturers should take this aspect into consideration in order not to establish a false front of low-emission EVs, which are operated with electricity from coal. As the global market for EVs is expected to grow, automotive manufacturers need to keep in mind that high acquisition costs and short driving ranges are the main factors that hamper the acceptance of EVs. By reducing energy consumption, range is being enhanced, which in turn can help to increase the acceptance of EVs. The findings of this paper suggest that mobile apps can help to reduce energy consumption and as a result contribute to lower CO_2 emissions and to increase the range of EVs.

4.6 Limitations and Future Research

Considering the precision of sample estimates, which is mainly affected by the sample size (Baroudi and Orlikowski 1989), the first limitation of this research relates to a small sample size (n = 33). This is due to the high amount of effort and time required to conduct the test drives under controlled conditions. Extraneous conditions must be controlled in order to reduce error variance caused by nuisance variables affecting the dependent variable (Kirk 2013; Whitley and Kite 2013). The participants drove a total of approximately 540 km with a total driving time of around 20 hours. Cohen (1992) argues that “the investigator needs to know the n necessary to attain the desired power for the specified α and hypothesized effect size,” and hereby refers to the balance between statistical power and the investigator’s resources (p. 156). The re-

sults of the statistical tests show that the statistical significance, the large effect size, and the statistical power of the results indicate a strong relationship among the variables. Nevertheless, further studies should explore a bigger sample size to further examine the results. Second, further factors could be considered such as proficiency in driving and behavior of the person. Differences in these factors could lead to further findings, for example, a smartphone-based driver assistance system could influence the energy-efficiency behavior of inexperienced drivers different from experienced drivers. Behavior of the person could also have an effect since individuals who have a defensive style of driving might react differently to the mobile app compared to individuals who usually drive aggressively. Further factors such as type of car, choice of route, time of day, and season of year could also be tested in order to investigate variances of results. Type of car can be important in terms of different types of car models, particularly in relation to the weight, engine, battery, tires, brakes, etc. The route can have an effect, because different routes implicate various speed restrictions and diverse traffic conditions. Furthermore, the road surface and height profile of the route can affect energy consumption. Referring to time of day, e.g., peak traffic times can have an impact. In this study, test drives were conducted during the day outside peak traffic times. Further studies could compare test drives at different times and various traffic situations. Season of year can also be relevant for energy consumption due to the influence of temperature on the battery of EVs and thus energy consumption and range (Qin et al. 2015). Third, in terms of generalizability, another limitation relates to the demographic characteristics of the sample. Most of the participants were male and under 30 years old (see Appendix 4 Table A1). While the participants may fall into the category of target users for mobile apps, care must be taken when choosing an approach to generalize the findings beyond the confines of the sample. Further research is recommended to repeat this study with a more diverse sample for enhanced generalizability. Fourth, since cultural differences are not part of this study, a further limitation is that the test drives were conducted in Germany due to regional proximity. Therefore, measures in other countries may lead to dif-

ferent results. Further research should be conducted in other countries to generate insights into the context of cultural differences regarding the impact of smartphone-based driver assistance systems on the energy consumption of EVs.

In order to further develop this research, additional test drives were conducted from July 10, 2015 to December 19, 2015. The participants were interviewed about their experience with the mobile app. For consistency reasons, “Smooth Driver” was used again during the test drives. Some participants reported that they were distracted by the mobile app, especially through the sound signal, which is sent to the driver for each fail (each time the ball falls out of the bowl; see Figure 12 for a screenshot of the mobile app). The participants explained that the sound signal induced stress, which they needed to cope with, because the sound signal distracted from paying attention to the traffic. According to the transactional stress model (Lazarus and Folkman 1984), stress is defined as “a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being” (p. 19). Particularly in a situation when being distracted while driving a car, the driver is confronted with the threat to cause an accident. Thus, his or her well-being is endangered due to a distraction, which can evoke stress in the driver. This leads to the proposition that perceived stress will affect the adoption of the mobile app. “Smooth Driver” is designed as a mobile gamification app, which is not completely productivity-oriented, but has a substantial entertainment dimension. Many other developed IS are considered to be entertainment-oriented such as online games, blogs, and social networking sites (Wang and Scheepers 2012). These entertainment-oriented IS are termed hedonic IS by van der Heijden (2004). In the context of smartphone-based driver assistance systems, the construct of perceived stress is proposed to be integrated into van der Heijden’s model of hedonic system adoption in order to measure the impact of drivers’ perceived stress on the intention to use the mobile app (see Figure 15).

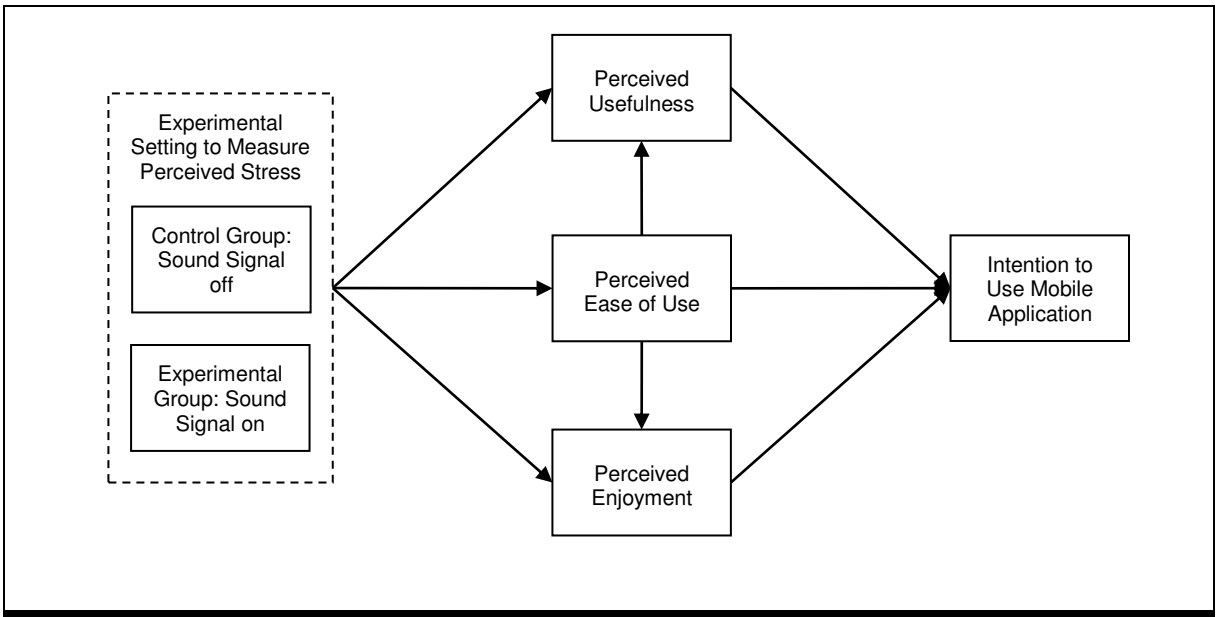

Figure 15. Theoretical Model for Future Research

In order to measure perceived stress, an experimental setting is recommended to be developed by defining a control group and an experimental group. The participants of the control group would be assigned to drive using the mobile app with the sound signal off, while turning the sound signal on for the participants of the experimental group. To measure the participants' hedonic system adoption, the survey instrument used in van der Heijden's (2004) study is recommended. A theoretical contribution is expected with regard to gaining new insights in terms of the question why smartphone-based driver assistance systems are either accepted or rejected. Furthermore, recommendations can be derived for automotive manufacturers to better address the challenge of reducing energy consumption by accurately designing mobile apps for energy reduction.

5. Conclusions and Outlook

Since Apple launched the iPhone in 2007, the landscape for mobile information systems has changed substantially (Sørensen et al. 2015). There are diverse, emerging topics in the field of mobile IS research, of which three aspects are explored in this doctoral thesis: information security, information privacy, and environmental sustainability.

Considering security aspects of mobile IS, the influence of cultural differences on employees' intention to use personal mobile devices for work is analyzed. As the importance of mobile devices has increased over the last decade, the trend of employees using their personal mobile devices for work has intensified and already begun to impact organizations. In IT consumerization, BYOD combines personal ownership and organizational use, thus several advantages and concerns for both employees and organizations come into existence. In IS research, literature on BYOD mainly addresses BYOD behavior and security issues, although the topics of BYOD in education, culture, status quo, and outcomes from BYOD also have drawn attention. Due to multifaceted characteristics of the implementation of BYOD, cultural differences are an important aspect for global organizations to have a successful implementation. This study focuses on cultural differences of BYOD regarding employees' behavioral intention. For this reason, the cultural dimensions theory is used to compare three cultures of choice for this study: the United States (Anglo-American culture), Germany (Central European culture), and South Korea (Asian culture). Assumptions for an impact of cultural differences on the intention to use BYOD have been derived from the cultural dimensions of power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. The results from structural equation modeling indicate that cultural differences among American, German, and Korean employees significantly affect the intention of bringing their own devices to work. The largest difference was found with the influence of perceived uncertainty toward

BYOD on the attitude with the highest influence for the United States ($\beta = -0.46$, $p < 0.001$), the second highest influence for Germany ($\beta = -0.34$, $p < 0.001$), and no significant influence for South Korea ($\beta = -0.14$, $p > 0.05$). We conclude that this large difference is due to the fact that individualist cultures, like the United States and Germany, pursue individual interests and therefore are more concerned about security, privacy, and legal issues that could harm the individual self, compared to collectivist cultures like South Korea, which place more importance on collective interests. Further differences are identified and discussed for cross-cultural comparisons. With regard to BYOD behavior and security issues, three classes of concerns that significantly impact employees' intention to use BYOD are recognized. Hence, a secure infrastructure (along with network, application, and device security), privacy policies, and a legal framework are needed for organizations that plan to implement BYOD, particularly organizations from individualist cultures, in order to reduce uncertainty. In mobile IS security research, the consumerization of IT has received considerable attention over the last several years. Employees and organizations can improve productivity, flexibility, and job satisfaction through IT consumerization by allowing them to choose the best devices for their needs. Besides BYOD as discussed in this thesis, "choose your own device" (CYOD) may follow the BYOD lead, allowing employees to choose an organization-owned device for work purposes. Recently on the scene, the corporate-owned, personally enabled (COPE) strategy lets employees choose a company-owned device and use their own apps as well as corporate apps on the device. Although BYOD, CYOD, and COPE vary in terms of cost sharing, they share the fundamental principles, such as security implications (Absalom 2014). Due to the ongoing discussion of the BYOD phenomenon, a continuing increase in the theoretical and practical importance of the topic is expected. Furthermore, a discussion of cultural challenges of BYOD is anticipated regarding several aspects, such as considerations of work−life balance and work−life blending, values of freedom and equality, the pursuit of material success and quality of life, and reflections on urgency and leisure time.

With regard to privacy aspects of mobile IS, the effect of mobile apps' access to personal information on mobile users' privacy concerns is tested with a structural equation model by conducting a survey of 474 mobile app users. Access to personal information is categorized into four dimensions: personal identity, location, device content, and system and network settings. The dimensions are identified by first selecting, installing, and analyzing permission requests of twelve popular mobile apps (such as Facebook, Twitter, Google Maps, WhatsApp Messenger, etc.), and then conducting a survey and testing collected data with principal component analysis using varimax rotation. Results of the structural equation modeling indicate that access to personal identity ($\beta = 0.25$, $p < 0.001$), location ($\beta = 0.21$, $p < 0.001$), and device content ($\beta = 0.23$, $p < 0.001$) are significantly positive in relation to mobile users' information privacy concerns. Access to system and network settings is not found to be significant ($\beta = –0.01$, $p > 0.05$). The results indicate that app providers should recognize access to personal identity, location, and device content as a significant indicator affecting MUIPC. Understanding mobile users' privacy concerns allows app providers to better address drawbacks resulting from those concerns. It is concluded that a trust-based relationship between app providers and users can help to build user confidence and overcome privacy concerns, for example, by pursuing approaches that relate to privacy assurances. Privacy assurance approaches include, e.g., the enabling of users to control the access to personal information (for example, turning off the location tracking from their mobile devices), privacy seals like TRUSTe, and privacy policies regulating the way personal information is managed. Considering IS privacy, there has been a call for research to investigate antecedents and consequences of information privacy concerns (Smith et al. 1996; Stewart and Segars 2002). In the last twenty years, concerns for information privacy (CFIP) have been investigated by several studies, which adapted CFIP to an online (see, e.g., Malhotra et al. 2004) and to a mobile context (see, e.g., Xu et al. 2012a). Especially since mobile apps are creating new economic opportunities for app providers, developers, software companies, and advertisers, mobile users' concerns for information

privacy have attracted considerable attention in IS research. Due to the access to personal information, mobile apps may pose a threat to users' privacy, which can incite users not to install or to uninstall mobile apps. For example, one aspect of app providers to react to mobile privacy issues is to give users control over their personal information. Since a recent reaction of Google with the release of Android 6.0 Marshmallow has been to follow Apple iOS as to turn off app permissions individually, mobile app privacy and app providers' continuing response (particularly of global market leaders Apple and Google) will be followed with great interest.

Referring to environmental sustainability aspects of mobile IS, the impact of smartphone-based driver assistance systems on the energy consumption of EVs is investigated. To test such an impact, a field experiment is conducted by defining a control group and an experimental group. Test drives are performed with an all-electric, lithium-ion battery powered, small passenger city car. As the treatment of the study, a mobile app is chosen that monitors excessive acceleration and hard braking. The results reveal significant differences among the groups ($t = 3.25$, $p < 0.01$) with a large effect size ($d = 1.15$, power = 0.97), which indicate that using smartphone-based driver assistance systems significantly reduces the energy consumption of EVs. This entails several benefits, including an increase of range of EVs, electricity cost savings, decrease of vehicle wear through energy-efficient driving, and reduction of greenhouse gas emissions. Results of the test drives show that subjects who drove the test route with the mobile app consumed approximately 10 percent less energy and required only a little more time (see Figure 14 for a comparison between the control group and the experimental group). This comparison shows that energy-efficient driving does not necessarily involve a delay in the time of arrival. Mobile apps that monitor excessive acceleration and hard braking can help to drive more energy-efficiently. Considering the competition among automotive manufacturers to lower operating costs and lower CO_2 emissions, automotive manufacturers should consider to provide driver assistance systems (smartphone-based or on-board) to

their customers that allow to control energy consumption. The domain of information systems for environmental sustainability and green information systems has grown in the last years. Considering the importance of global warming and climate change, the transportation sector has the potential to substantially reduce greenhouse gas emissions. In this context, EVs are regarded as a promising transportation alternative, given that electricity is produced from renewable energy sources.

Overall, the widespread adoption of mobile information systems such as smartphones and tablets will continue to affect society, and thus practice and research, as well. The number of mobile users is increasing continuously, offering organizations and companies the opportunity of engaging and monetizing mobile users more and more. Particularly in IS research, the topic of mobile information systems has drawn much attention. At IS conferences, whole conference tracks have been addressed to the topic of mobile IS, for example, the track “Ubiquitous and Mobile Information Systems” at the European Conference on Information Systems (ECIS) in 2013 in Utrecht, Netherlands, or the track “Decision Analytics, Mobile Services, and Service Science” at the Hawaii International Conference on System Sciences (HICSS) annually in the past few years. Mobile IS research articles are likewise increasingly being published in IS journals, notably also in the AIS basket of top journals, of which two have dedicated special issues to the topic: a special issue called “Mobile Computing” in the Journal of Information Technology (JIT) in 2009, and more recently “Mobile Information Systems and Mobility” in the European Journal of Information Systems (EJIS) in 2014. The topic of mobile information systems is anticipated to continue to attract attention in practice as well as in research.

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Appendix

Appendix 1: Investigating the Influence of Security, Privacy, and Legal Concerns on Employees' Intention to Use BYOD Mobile Devices

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Abstract: The concept of Bring-Your-Own-Device (BYOD) describes the trend of employees using their private mobile devices to manage corporate data from anywhere at any time. BYOD can increase employees' productivity and be cost-cutting for organizations. To implement BYOD, organizations are dependent on employees' acceptance of BYOD, because employees' participation usually is voluntary. As employees' acceptance is affected by uncertainty, we investigate the influence of security, privacy, and legal concerns on the intention to use BYOD mobile devices. A research model is developed based on the theory of reasoned action (TRA) and the technology acceptance model (TAM), which is tested by means of structural equation modeling (SEM) with data collected from 151 employees. Our results indicate a significant impact of the concerns on employees' acceptance. Moreover, our study reveals employees' indecision towards their intention to use their private mobile devices for working purposes. Several implications for future research and practitioners are given.

Appendix 2: Bring Your Own Device: Cultural Differences of Employees' Intention to Use Personal Mobile Devices for Work

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Abstract: In information technology consumerization, "bring your own device" (BYOD) describes the trend of employees using their personal mobile devices to access corporate data anywhere, anytime, and with various mobile devices. Advantages include the freedom to choose any device, an easier technology adoption, and an increased workforce availability when business needs occur. Disadvantages entail security threats, privacy concerns, and legal problems as well as increased workload for employees. Since BYOD is voluntary for employees, organizations that wish to successfully implement BYOD need to understand employees' behavior, which is mainly predicted from employees' intention to use their personal mobile devices for work purposes. Due to the versatile and international scope of BYOD, this study analyzes cultural differences between the United States (Anglo-American culture), Germany (Central European culture), and South Korea (Asian culture). We refer to the cultural dimensions theory and the theory of reasoned action, and test hypothesized relationships of employees' intention to use, based on a survey of 542 employees from three different cultures. Our results show that the most significant difference occurs for the construct of perceived uncertainty toward BYOD. American employees place the highest importance on perceived uncertainty, followed by German employees, with no significant impact for Korean employees.

BRING YOUR OWN DEVICE: CULTURAL DIFFERENCES OF EMPLOYEES' INTENTION TO USE PERSONAL MOBILE DEVICES FOR WORK[1]

In information technology consumerization, "bring your own device" (BYOD) describes the trend of employees using their personal mobile devices to access corporate data anywhere, anytime, and with various mobile devices. Advantages include the freedom to choose any device, an easier technology adoption, and an increased workforce availability when business needs occur. Disadvantages entail security threats, privacy concerns, and legal problems as well as increased workload for employees. Since BYOD is voluntary for employees, organizations that wish to successfully implement BYOD need to understand employees' behavior, which is mainly predicted from employees' intention to use their personal mobile devices for work purposes. Due to the versatile and international scope of BYOD, this study analyzes cultural differences between the United States (Anglo-American culture), Germany (Central European culture), and South Korea (Asian culture). We refer to the cultural dimensions theory and the theory of reasoned action, and test hypothesized relationships of employees' intention to use, based on a survey of 542 employees from three different cultures. Our results show that the most significant difference occurs for the construct of perceived uncertainty toward BYOD. American employees place the highest importance on perceived uncertainty, followed by German employees, with no significant impact for Korean employees.

Keywords: Bring your own device, BYOD, IT consumerization, cultural dimensions theory, theory of reasoned action, behavioral intention to use, mobile devices

[1] An earlier version of this paper won a Best Paper Award at an AIS conference [blinded for review].

BRING YOUR OWN DEVICE: CULTURAL DIFFERENCES OF EMPLOYEES' INTENTION TO USE PERSONAL MOBILE DEVICES FOR WORK

INTRODUCTION

"Bring your own device" (BYOD) has emerged in the course of the consumerization of information technology (IT) in the past several years (Chen 2014; French et al. 2014; Harris et al. 2013) and is common in many organizations (Miller et al. 2012). BYOD can be described as the use of employees' privately owned information system (IS) devices for work purposes (Lee et al. 2013; Loose et al. 2013), for example, to "access corporate applications like email and databases; and to create, store and manage corporate data using these devices" (Osterman Research 2012, p. 2). It is often linked to several advantages for both employees and organizations. From an employee's point of view, these are greater freedom and flexibility, increased motivation, as well as easier technology adoption (Niehaves et al. 2012). These benefits can lead to a higher job satisfaction (Osterman Research 2012). Since positive job satisfaction increases employees' productivity (Saari and Judge 2004), organizations can also benefit from BYOD (Dell 2011; Osterman Research 2012). The use of BYOD devices can increase employees' availability and thus the flexibility and mobility of the workforce when business needs occur. This flexibility allows employees to work from home or on the move with the result that business continuity does not suffer. These benefits provide an incentive for organizations to implement a BYOD strategy. A precondition for a successful BYOD implementation is understanding employees' behavior toward BYOD, because an implementation usually depends on the employees' voluntary participation. However, BYOD creates a "unique set of challenges for IT professionals" (Johnson and Joshi 2012, p. 1) as it "redefines the relationship between employees … and the IT organization" (Niehaves et al. 2012, p. 1). These challenges refer to instances such as the disadvantage of the added pressure

of more workload at the expense of the private lives of employees (Chen 2014; Köffer et al. 2014; Loose et al. 2013; Niehaves et al. 2012). In addition, the implementation of a BYOD strategy can entail security threats, privacy concerns, and legal problems (Donaldson et al. 2015; Miller et al. 2012; Osterman Research 2012; Silverglate and Salner 2011).

From an economic perspective, Cisco's Internet Business Solutions Group (IBSG) predicts use of BYOD devices will grow from 198 million in 2013 to 405 million by 2016 in global workplaces (Cisco IBSG 2013). The United States (71 million BYOD devices in 2013), China (63 million), and India (32 million) are the largest markets, followed by Brazil (12 million), Germany (11 million), and the United Kingdom (8 million) (Cisco IBSG 2013). In other countries, BYOD has also emerged as the rising trend to watch. For example, IDG Connect (2014) surveyed 300 IT managers in Australia, India, South Korea, and Taiwan, and found out that only 9 percent of the organizations stated employees are not allowed to bring their own devices to work. According to a survey by the CyberEdge Group (2014), which was conducted in North America and Europe, more than 75 percent of responding organizations will have BYOD policies in place by 2016.

BYOD is a global phenomenon with international characteristics, which is why this research field not only requires security considerations, but also a focus on cultural aspects regarding a better understanding of employees' behavior toward BYOD for organizations acting in a multinational and multicultural environment. From a global perspective, according to Hofstede et al. (2010), people are confronted with common challenges worldwide, but their behaviors differ from each other—not only at the individual level, but at the cultural level as well. Hofstede (2015) defines culture as "the collective programming of the mind distinguishing the members of one group or category of people from another" (p. 2).

Therefore, cross-cultural challenges demand a structured comprehension of the differences, because "although the variety in people's minds is enormous, there is a structure in this variety that can serve as a basis for mutual understanding" (Hofstede et al. 2010, p. 4). From an IS perspective, understanding cultural differences is crucial for global organizations to successfully deploy information technology (Myers and Tan 2002). Recent studies in IS research have placed emphasis on the cultural impact on information systems (e.g., Chang et al. 2015; Zhou et al. 2015), thereby also considering a cultural perspective for mobile information systems (e.g., Hoehle et al. 2015).

This paper investigates cultural differences of BYOD regarding employees' intention to use personal mobile devices for work, because mobile devices such as smartphones and tablets are most commonly used for BYOD practices (Cisco IBSG 2013). The employees' intention to use is measured using the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989). Considering employees' concerns for security issues, we adapted Pavlou et al.'s (2007) research model to measure the construct of perceived uncertainty, which we hypothesize is influenced by security, privacy, and legal concerns. With regard to cultural issues, following the cultural dimensions theory (Hofstede et al. 2010), cultural differences among employees in the United States, Germany, and South Korea are explored in this study to cover a diverse field of cultural differences as an initial step. In fact, BYOD is not only an industry trend, but it has become integral to enterprise-wide operations and IT organizations. We have chosen to explore more of the differences among cultures and how that plays a role as organizations incorporate BYOD. Hence, we selected mature countries leading the IT sector: the United States as a representative country for the Anglo-American culture, Germany on behalf of the Central European culture, and South Korea representing the Asian culture. Referring to a report by

eMarketer, these three nations have a similar, high percentage of smartphone users, with an expected share of 79.7 percent of mobile phone users in the United States, 80.0 percent in Germany, and 84.8 percent in South Korea by 2017 (McDermott 2013). Smartphones are considered to have the highest potential for BYOD usage. Furthermore, BYOD is a growing trend in the United States and Germany (Cisco IBSG 2013) as well as in South Korea (IDG Connect 2014). This approach attempts to offer recommendations for global organizations that are planning to implement a BYOD strategy in a multinational and multicultural context for cross-cultural communication.

The article focuses on the following three perspectives. First, the six cultural dimensions according to Hofstede et al. (2010)—power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence—are compared among the United States, Germany, and South Korea to investigate cultural differences. Second, an operationalization of the employees' intention to use BYOD is offered with a focus on security issues to measure differences among American, German, and Korean employees. Third, a causal model on the employees' intention to use is proposed and tested by conducting a survey in order to analyze influencing factors and to examine differences between employees from these three cultures. This paper makes a theoretical contribution by conceptualizing employees' intention to use BYOD and by investigating cultural differences. A review of the literature in the area of BYOD shows that most of the articles focus on behavior and security; the cultural aspects of BYOD, however, have drawn little attention. To analyze the cultural differences as an initial step, in this study the focus is on the United States, Germany, and South Korea. The research question is as follows:

To what extent do cultural differences of bring your own device exist between American, German, and Korean employees' intention to use personal mobile devices for work?

The paper is structured as follows: first, a literature review on the topic of BYOD is conducted. Second, cultural differences among the United States, Germany, and South Korea are compared according to the cultural dimensions theory. Third, after developing the research model and the hypotheses, the research design is motivated and the findings of the survey are discussed. Fourth, implications for research and practice as well as recommendations are presented. Finally, limitations, conclusions, and an outlook are provided.

THEORETICAL BACKGROUND AND FOUNDATION

In IS research, the topic of BYOD has drawn attention predominantly at IS conferences. To give an overview of the current BYOD research, a literature review was conducted on six major IS research databases: ACM, AISeL, IEEE, Science Direct, EBSCOhost, and SpringerLink. The keywords "bring your own device" and "BYOD" were used to search titles of the relevant literature, which has a strong focus on IS research. The articles were identified in the proceedings of the Americas Conference on Information Systems (AMCIS), European Conference on Information Systems (ECIS), International Conference on Information Systems (ICIS), and Pacific Asia Conference on Information Systems (PACIS) and in the following journals: Business & Information Systems Engineering (BISE) and Communications of the Association for Information Systems (CAIS). The identified articles mainly deal with BYOD behavior and security issues. Further topics include BYOD in education, culture, status quo, and outcomes from BYOD (see Table 1).

Table 1. Overview of BYOD Literature in IS Research			
Authors	**Significant Findings**	**Outlet**	**Research Focus**
Buettner 2015	Perceived enjoyment is found to be a significant predictor for the usage intensity of personal mobile devices for work.	AMCIS	Behavior
Chen 2014	A proposed research model is presented to measure the effects of flexibility and task complexity on BYOD intention (research-in-progress paper).	AMCIS	Behavior
French et al. 2014	A summary of a panel discussion at the AMCIS 2013 to the current status, issues, and future direction of BYOD.	CAIS	Status quo
French et al. 2015	Significant differences between the United States and South Korea regarding BYOD in class are found conducting a single factor ANOVA.	AMCIS	Education/ Culture
Harris et al. 2013	A survey of 131 college students shows that their mobile devices are poorly secured, which is why organizations are recommended to start with mobile device security awareness and training for BYOD.	AMCIS	Security
Hopkins et al. 2013	BYOD intention in class is substantially influenced by attitude and moderately influenced by subjective norm and perceived behavioral control.	ECIS	Education/ Behavior
Köffer et al. 2015	Results of a structural equation modeling show that BYOD usage significantly influences individual IT innovation behavior in the workplace.	BISE	Behavior
Lee et al. 2013	A proposed research model is presented to measure the impact of monitoring mechanisms, privacy concerns, and job performance expectancy on BYOD intention (research-in-progress paper).	ICIS	Behavior
Loose et al. 2013	BYOD intention is found to be a significant predictor for the attractiveness of a company for future employees offering the possibility to use personal mobile devices for work.	AMCIS	Behavior
Ortbach 2015	Personal innovativeness significantly influences perceived ease of use of privately owned and company-owned devices; perceived usefulness of privately owned devices is the most important predictor for BYOD intention.	ECIS	Behavior
Ortbach et al. 2015	A proposed survey of IS executives is presented that will investigate the effects of trust and risk on BYOD policy decisions, which in turn influences IS service quality (research-in-progress paper).	ECIS	Security
Putri and Hovav 2014	Employees' compliance with BYOD security policy is significantly affected by perceived response efficacy.	ECIS	Security
Tu and Yuan 2015	A survey of IS executives will be conducted to identify factors affecting organizations' coping with BYOD security threat (research-in-progress paper).	AMCIS	Security
Weeger and Gewald 2014	Perceived risk, perceived benefits, and personal innovativeness are found to be significant predictors of BYOD intention.	ECIS	Security/ Behavior
Yin et al. 2014	The authors plan to conduct interviews with employees and executives about benefits, costs, expectations, goals, and outcomes of BYOD followed by a survey for hierarchical linear modeling (research-in-progress paper).	PACIS	Outcomes

As the purpose of this study is to examine cultural differences of employees' intention to use BYOD, we use the cultural dimensions theory (Hofstede et al. 2010) for the focus countries in this study (the United States, Germany, and South Korea) in order to set a theoretical foundation for cultural differences. Then, we use the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the technology acceptance model (TAM) (Davis et al. 1989) to develop our research model and generate the hypotheses.

Cultural Dimensions Theory

To investigate employees' intention to bring their own devices from a cultural perspective, we focus on the cultural dimensions theory and examine cultural differences among the United States, Germany, and South Korea. In the cultural dimensions theory, culture is classified into six categories: power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence (Hofstede et al. 2010). Figure 1 shows the culture scores for the United States, Germany, and South Korea, with a range from 0 to 100. The scores are relative, meaning that culture can be only used meaningfully by comparison (Hofstede et al. 2010).

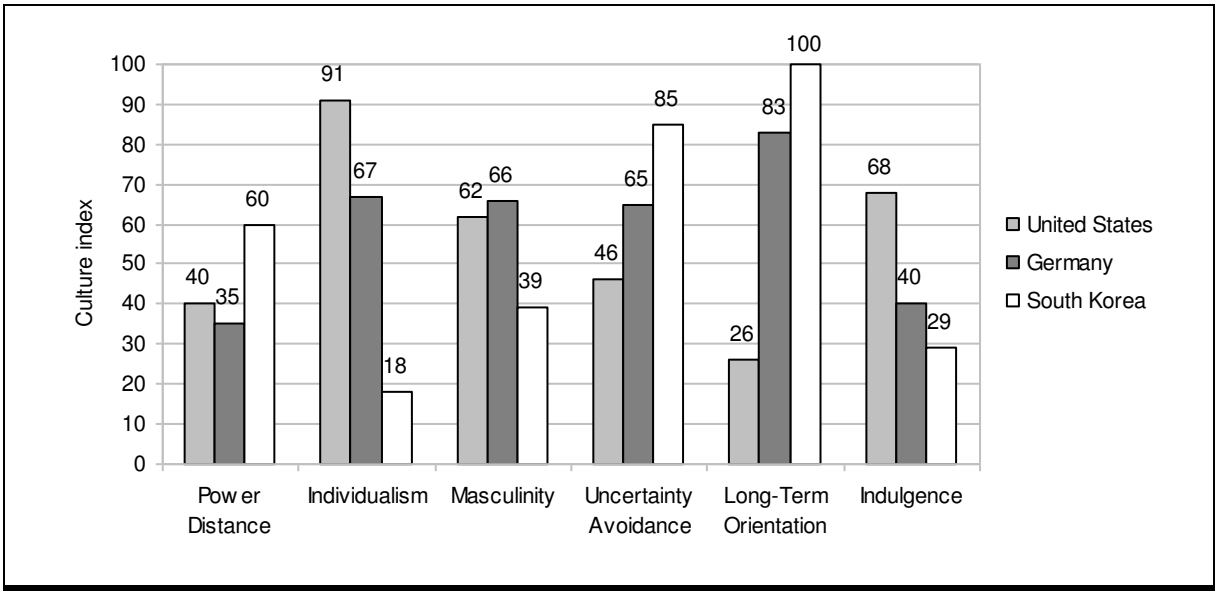

Figure 1. Cultural Dimensions for the United States, Germany, and South Korea

Power distance is defined as "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" (Hofstede et al. 2010, p. 61). Within the context of BYOD, power distance may imply that employees expect to be consulted whether BYOD should be implemented (low power distance) or employees expect to be told what to do (high power distance). Thus, we assume that employees' attitude toward BYOD will be less important for high power distance

cultures, because employees' intention to bring their own devices will not mainly depend on their attitude.

Individualism refers to "societies in which the ties between individuals are loose: everyone is expected to look after him- or herself and his or her immediate family. Collectivism as its opposite counterpart, pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty" (Hofstede et al. 2010, p. 92). Hofstede et al. also point out that there is a negative correlation between power distance and individualism. Many countries with a high score on power distance score low on individualism, which is the case for the United States, Germany, and South Korea (see Figure 1). Individualist countries place importance on freedom, independence, and individual interests, whereas collectivist countries value equality, interdependency, and collective interests. With regard to BYOD, individualism may imply that employees prefer the freedom to use their own devices without being dependent on systems provided by the organization. In contrast, collectivism may imply that employees prefer equality to the effect that all employees use the same device provided by the organization. There could be a propensity for being interdependent with the organization's processes and structure, which also suggests a preference for company devices in collectivist countries. Employees from collectivist countries may prioritize the organization's intention to implement BYOD policies over the risk of running into security issues with corporate data such as data theft or loss of device, disclosing personal information such as personal profiles on social networks, personal emails, and personal photos, or experiencing legal complications regarding work time regulations, accounts of charges, or commitment to maintenance.

Masculine and feminine societies are defined as follows: “A society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap: both men and women are supposed to be modest, tender, and concerned with the quality of life” (Hofstede et al. 2010, p. 140). BYOD encourages to increasing productivity by work−life blending enabled by the usage of personal devices for work purposes. Thus, we assume that masculine countries would prefer BYOD in order to increase performance and achieve material success, whereas feminine countries would rather decline BYOD due to a distinct separation of work hours and leisure time supporting work−life balance for an enhanced quality of life.

Uncertainty avoidance is defined as “the extent to which the members of a culture feel threatened by ambiguous or unknown situations. This feeling is, among other manifestations, expressed through nervous stress and in a need for predictability: a need for written and unwritten rules” (Hofstede et al. 2010, p. 191). Hofstede et al. clarify that uncertainty avoidance should not be confused with risk avoidance, but rather that uncertainty-avoiding cultures are often prepared to engage in risky behavior in order to reduce ambiguities. For example, stronger uncertainty avoidance can lead to faster driving, taking a familiar risk to reduce ambiguity. Thus, in uncertainty-avoiding cultures there is a sense of stress and urgency. As a consequence, uncertainty-avoiding cultures may take the risk of implementing BYOD in order to increase urgency and to save time while simultaneously, meeting the need for precise rules. In this instance, BYOD policies clearly define principles and guidelines for the usage of personal devices for work purposes.

Long-term orientation describes "the fostering of virtues oriented toward future rewards—in particular, perseverance and thrift. Its opposite pole, short-term orientation, stands for the fostering of virtues related to the past and present—in particular, respect for tradition, preservation of 'face,' and fulfilling social obligations" (Hofstede et al. 2010, p. 239). One major distinction in the work environment between long-term and short-term oriented cultures is the importance of leisure time and the perspective of work−life balance. While short-term oriented cultures consider leisure time to be important, it is of less importance for long-term oriented cultures. Furthermore, in long-term oriented cultures, family and work are not separated. Similar to the dimension of masculinity, long-term oriented cultures encourage work−life blending, while short-term oriented cultures strive for work−life balance. This is further emphasized by the concept of *guanxi*, which describes the necessity of a personal network of acquaintances for success in Chinese society. *Guanxi* refers to personal connections, linking the family sphere to the business sphere. The work−life blending characteristic of *guanxi* is similar to BYOD, allowing personal contacts to be interwoven into business needs. We assume that perceived benefits of BYOD will be more important for long-term oriented cultures.

Indulgence stands for "a tendency to allow relatively free gratification of basic and natural human desires related to enjoying life and having fun. Its opposite pole, restraint, reflects a conviction that such gratification needs to be curbed and regulated by strict social norms" (Hofstede et al. 2010, p. 281). Besides life satisfaction and happiness, the importance of leisure is one distinct characteristic, which differentiates indulgent societies from restraint societies. Hofstede et al. also point out that in indulgent societies, email and the Internet are more frequently used for private contacts. In terms of BYOD, using personal devices for work purposes could implicate an intrusion in employees' leisure time and quality of life due to

employees' increase in workload. On the other hand, BYOD entails the communication with private contacts during work hours. Consequently, employees from indulgent societies could refuse to use BYOD due to an intrusion into leisure time, but simultaneously could endorse BYOD due to the opportunity to communicate with private contacts during work hours.

Table 2. Assumptions for Cultural Influence on BYOD Intention

Cultural Dimension	Degree	Assumption	BYOD Intention
Power Distance Index (PDI)	High PDI	Employees' attitude less important	o
	Low PDI	Employees' attitude important	o
Individualism versus Collectivism (IDV)	Individualism	Freedom to use own devices	+
		Independent of corporate system	+
		High concerns due to individual interests	-
	Collectivism	Preference for corporate device (equality)	-
		Interdependent with organization	-
		Low concerns due to collective interests	+
Masculinity versus Femininity (MAS)	Masculinity	Work−life blending (material success)	+
	Femininity	Work−life balance (quality of life)	-
Uncertainty Avoidance Index (UAI)	High UAI	Work−life blending (need for urgency)	+
		BYOD policies important (need for precise rules)	o
	Low UAI	Work−life balance (relaxed behavior)	-
		BYOD policies less important (tolerance for ambiguity)	o
Long-Term Orientation versus Short-Term Orientation (LTO)	LTO	Work−life blending (lifelong personal networks)	+
	STO	Work−life balance (variation of personal networks)	-
Indulgence versus Restraint (IVR)	Indulgence	High importance of leisure	-
		Email and Internet used for private contacts	+
	Restraint	Low importance of leisure	+
		Less use of email and Internet for private contacts	-

Legend: + (positive influence on BYOD intention), o (neutral influence), - (negative influence)

Table 2 summarizes the cultural dimensions and the assumed impacts they can have on employees' BYOD intention. Since the blending of work and life is one major characteristic of BYOD, according to the assumptions made, cultural differences regarding work−life balance can have a major impact on employees' intention to use BYOD. Besides the work−life balance, further aspects should be taken into consideration, for example, the values

of freedom and equality, the pursuit of material success and quality of life, the need for urgency, and the importance of leisure.

Hypothesis Generation

In order to empirically investigate cultural differences of BYOD with regard to employees' intention to use, it is important to explain behavioral intention in the first place. Behavioral intention has been employed as the key dependent variable to describe user acceptance of IT in numerous studies (e.g. Davis 1989; Nysveen et al. 2005; Taylor and Todd 1995; Venkatesh and Davis 1996). Ajzen (1991) defines behavioral intention as an indication "of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (p. 181). In the context of this study, the behavior is the actual usage of BYOD mobile devices. According to the theory of reasoned action (TRA) (Fishbein and Ajzen 1975), the most immediate antecedent of behavioral intention is attitude, which is defined as "an individual's positive or negative feelings (evaluative affect) about performing the target behavior" (Davis et al. 1989, p. 984). Considering cultural differences among the United States, Germany, and South Korea, we propose the following hypothesis:

H1: *The positive relationship between BYOD attitude and intention to use will be significantly different for American, German, and Korean employees.*

Attitude relates to beliefs about consequences of behavior and the evaluation of those consequences (Fishbein and Ajzen 1975). In view of beliefs, Oliver and Bearden (1985) distinguish between benefits and problems, both of which are associated with the behavior.

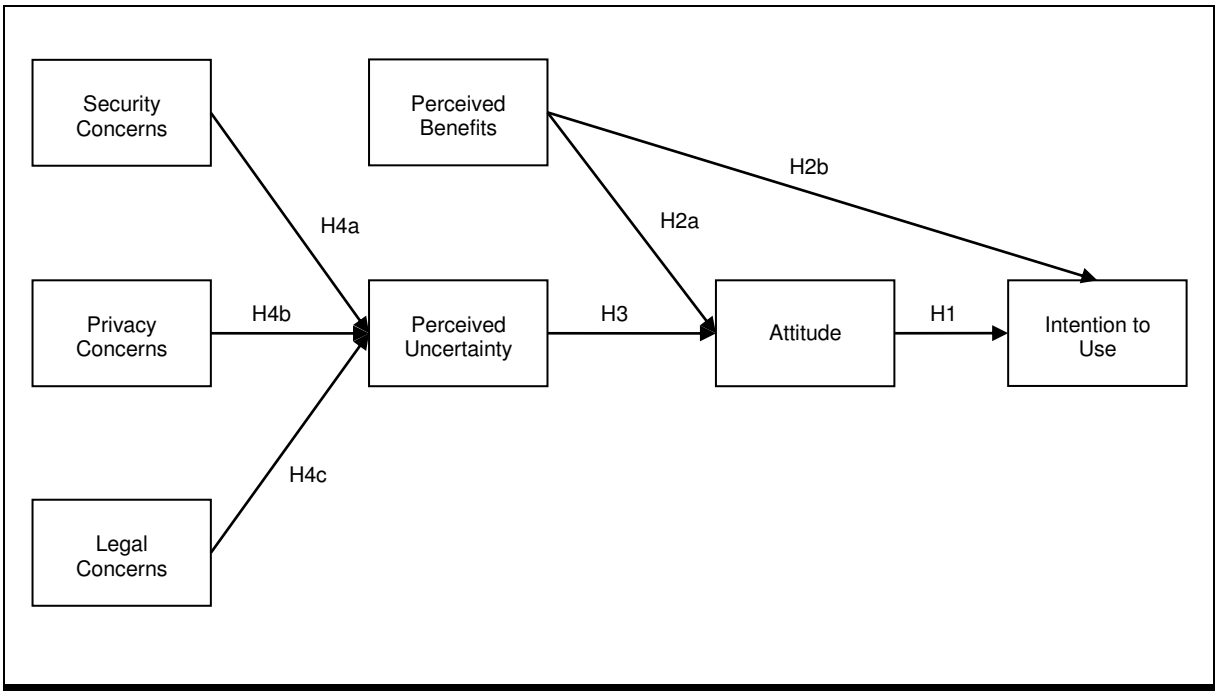

Figure 2. Proposed Research Model

With regard to benefits in the context of IT at the workplace, Davis (1989) indicates that people are motivated to use a system that helps them perform their jobs. He explains that "people are generally reinforced for good performances by raises, promotions, bonuses, and other rewards" (p. 320). These benefits are indicated as perceived usefulness, which is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis 1989, p. 320). The technology acceptance model (TAM) postulates that perceived usefulness affects attitude due to positively or negatively valued outcomes. In addition, it is hypothesized that perceived usefulness has a direct influence on intention, because "within organizational settings, people form intentions toward behaviors they believe will increase their job performance, over and above whatever positive or negative feelings may be evoked toward the behavior per se" (Davis et al. 1989, p. 986). In this context, the word useful means "capable of being used advantageously" (Davis 1989, p. 320).

According to several studies, BYOD entails advantages for both employees and organizations. For example, a study by Dell (2011) revealed that granting employees more privileges toward a more mobile workplace increases the overall productivity within an organization. Moreover, by allowing employees to choose their mobile work devices, their individual efficiency could be enhanced. A study by Osterman Research (2012) revealed similar results concerning employees' productivity and efficiency. The study explains the gain in employees' productivity and efficiency by higher job satisfaction. This is the result of increased personal freedom since employees can use their preferred mobile devices in their favored locations and time. We hypothesize cultural differences regarding the influence of perceived benefits of BYOD mobile devices on attitude and intention to use.

In view of problems within the frame of organizational IT, the construct of uncertainty has been in the focus of several studies (e.g., Harnesk and Lindström 2011; Spears and Barki 2010). Uncertainty can be defined as "the degree to which the future states of the environment cannot be accurately anticipated or predicted due to imperfect information" (Pavlou et al. 2007, p. 107). Considering the usage of BYOD mobile devices, we define perceived usefulness as perceived benefits and problems as perceived uncertainty and adapt these constructs to our research model in a cultural setting.

H2: *The positive relationship between perceived benefits of BYOD and (a) attitude and (b) intention to use will be significantly different for American, German, and Korean employees.*

H3: *The negative relationship between perceived uncertainty of BYOD and attitude will be significantly different for American, German, and Korean employees.*

Pavlou et al. (2007) propose that perceived uncertainty is influenced by security concerns and privacy concerns. In the context of BYOD, legal concerns are considered to be a third factor influencing uncertainty (Miller et al. 2012; Osterman Research 2012; Silverglate and Salner 2011).

Security concerns can be defined as "the level to which an employee believes that her/his organizational information assets are threatened" (Herath and Rao 2009, p. 111). In academic literature, there is agreement that the implementation of mobile technology into organizations entails information security concerns (e.g., Beulen and Streng 2002; Giessmann et al. 2012; Scheepers and Scheepers 2004). With the use of BYOD mobile devices, corporate information security is exposed to new risks (Niehaves et al. 2012; Tu and Yuan 2012). In contrast to company-owned devices, privately owned devices provide a greater likelihood of potential violations of the corporate information security policies, as regulations cannot usually be enforced on those devices (Miller et al. 2012; Osterman Research 2012). This results in two general threats to corporate information security: On the one hand, the integration of privately owned devices into corporate network facilitates malware intrusion (e.g., viruses, worms, trojans). On the other hand, it also increases the possibility of data loss and theft (Miller et al. 2012).

In terms of privacy concerns, Minch (2004) defines privacy as "the claim of individuals, groups, or institutions to determine for themselves when, how, and to what extent information about them is communicated to others" (p. 2). These concerns are related to a "possible loss of privacy as a result of information disclosure" (Xu et al. 2008, p. 4). Similar to the aspect of information security, end user privacy concerns in the context of mobile device usage received plenty of attention from scholars (e.g., Figge et al. 2003; Ho 2009). The existing

academic literature mostly deals with the aspect of privacy of end users with regard to mobile service providers (e.g., mobile banking, mobile commerce, location-based services). Findings suggest that privacy concerns do affect an end user's acceptance of mobile services. Ho (2009) shows that end users may be afraid of being tracked and may worry that private data on their devices can be abused. In the context of BYOD, Miller et al. (2012) suppose that the privacy aspect is potentially more important than the security aspect. They indicate that difficulties in differing between private and organizational data occur if employees use their privately owned devices in an organizational context. The installation of mobile device management and mobile application management software may be required to secure (e.g., virus protection), monitor, manage (e.g., data synchronization), and support BYOD mobile devices. This is why organizations could be able to track employees' locations during work and non-work hours, which applications they have installed, and access personal data such as private emails and private photos (PR Newswire 2012).

In addition to security and privacy concerns, BYOD is also associated with legal concerns (Osterman Research 2012; Silverglate and Salner 2011). In general information security research, the legal perspective is often linked to privacy (e.g., Earp et al. 2002; Kayworth 2005). In this study, legal concerns refer to existing statutory regulations between employers and employees. For example, Silverglate and Salner (2011) indicate that the use of BYOD mobile devices causes violations of work hour regulations as employees "stay connected to their jobs on nights, weekends and even vacations" (p. 41). A consequence would be that employees demand compensation for their expanded work time (Silverglate and Salner 2011). Furthermore, we assume that employees are concerned about being held liable if corporate information is lost due to loss, theft or damage to their device.

Due to the importance of security, privacy, and legal concerns regarding BYOD, we propose the following hypothesis, taking account of cultural differences between the United States, Germany, and South Korea:

> ***H4:*** *The positive relationship between perceived uncertainty of BYOD and (a) security concerns, (b) privacy concerns, and (c) legal concerns will be significantly different for American, German, and Korean employees.*

RESEARCH DESIGN

For our empirical exploration, we designed a survey and distributed it to participants from the United States, Germany, and South Korea via an online survey (via social networking sites, email, and personal recruitment through professional networking) and written submissions. The first two questions were designed to eliminate participants who were neither employed nor privately owning a mobile device. These restrictions concerning the target group allowed us to accurately measure the hypothesized constructs. To reduce bias, the questionnaire was provided in the English, German, and Korean languages (see Table A1 in Appendix A for the survey instrument). Prior to the main test, seven pretests were conducted. The pretests were realized by means of intensive discussions with the participants in order to receive feedback concerning the validity and comprehensibility of the survey questions. Multiple item constructs were chosen using a five-point Likert scale, which ranged from "strongly disagree" to "strongly agree." In total, 542 participants (i.e., employees from major cities in the United States, Germany, and South Korea) produced usable data, with 210 from the United States, 178 from Germany, and 154 from South Korea. As shown in Table A2 in Appendix A, the responding participants (overall) are well represented in gender, age, size of the organization,

and industry, along with the participants' knowledge of computers and IT, and information sensitivity of the organization.

Data Analysis

To test the proposed research model, structural equation modeling (SEM) was conducted using SmartPLS version 2.0.M3 (Ringle et al. 2005). SEM provides the ability to model relationships among multiple predictor and multiple criterion variables, which is why SEM is appropriate for analyzing multivariate models (Chin 1998). All indicators were modeled as being reflective of their respective constructs. Concerning the predictiveness of the model, factor loadings should be "at least 0.60 and ideally at 0.70 or above, indicating that each measure is accounting for 50 percent or more of the variance of the underlying LV [latent variable]" (Chin 1998, p. xiii). The measurement items in the model of this study load between 0.68 and 0.95 on their respective constructs (see Table B1 in Appendix B for factor loadings), thus demonstrating adequate reliability. The internal consistency of the scales was validated with the analysis of Cronbach's alpha ranging from 0.87 to 0.95, and composite reliability (CR) ranging from 0.91 to 0.96. To establish acceptable model reliability, the recommended values for construct reliability are above 0.70 (Gefen et al. 2000); the internal consistency criteria are therefore met. An indicator for convergent and discriminant validity is the average variance extracted (AVE), which ranges from 0.72 to 0.88. Fornell and Larcker (1981) recommend a lower limit of 0.50 for convergent validity. For discriminant validity, the square root of the AVE should be greater than the variance shared between the construct and other constructs in the model (Wixom and Todd 2005; Xu et al. 2013). Table 3 provides the correlation matrix with correlations among constructs and the square root of the AVE on the diagonal. In all cases, the square root of the AVE for each construct is larger than the correlation of the construct with all other constructs in the model.

Table 3. Correlation Matrix

	SEC	PRI	LEG	UNC	BEN	ATT	INT	CUL	SEX	AGE	EXP	EMP	IND	SEN	PER
SEC	0.85														
PRI	0.40	0.85													
LEG	0.37	0.59	0.87												
UNC	0.49	0.60	0.63	0.92											
BEN	–0.20	–0.05	–0.05	–0.17	0.91										
ATT	–0.28	–0.25	–0.22	–0.42	0.58	0.89									
INT	–0.29	–0.25	–0.23	–0.39	0.48	0.73	0.94								
CUL	0.15	–0.13	–0.23	–0.06	–0.16	–0.02	–0.11	1.00							
SEX	–0.09	0.11	0.14	0.09	0.04	–0.07	0.05	–0.42	1.00						
AGE	0.12	0.04	–0.03	0.05	0.07	0.05	–0.03	0.31	–0.30	1.00					
EXP	0.07	–0.02	–0.01	–0.05	0.08	0.14	0.13	0.13	–0.19	0.12	1.00				
EMP	0.15	0.08	0.08	0.07	–0.14	–0.13	–0.12	0.10	–0.15	0.15	0.07	1.00			
IND	–0.10	–0.08	–0.08	–0.10	0.05	0.08	0.12	–0.18	0.05	–0.12	0.01	–0.19	1.00		
SEN	0.15	0.04	0.13	0.04	–0.08	–0.14	–0.12	0.00	0.04	0.06	0.08	0.23	–0.09	1.00	
PER	0.19	0.15	0.17	0.17	–0.18	–0.24	–0.27	0.10	0.00	0.01	–0.09	0.18	–0.07	0.11	1.00

Notes: SEC = security concerns, PRI = privacy concerns, LEG = legal concerns, UNC = perceived uncertainty, BEN = perceived benefits, ATT = attitude, INT = intention to use, CUL = culture, SEX = gender, AGE = age, EXP = IT experience, EMP = number of employees, IND = industry, SEN = sensitivity of corporate data, PER = permission to use personal mobile device for work purposes; value on the diagonal is the square root of average variance extracted (AVE)

Convergent and discriminant validity are further assessed observing cross loadings in the model. All items should load more highly on their constructs (above 0.50) than they load on any other constructs (Wixom and Todd 2005; Xu et al. 2013), and in all cases the items in this study load above 0.68 and the differences are greater than 0.10 with most of them greater than 0.25 (see Table B1 in Appendix B for loadings and cross loadings). Due to a variation between the subject groups concerning the ratio of the demographic variables (i.e., gender, age, IT knowledge, etc.), we conducted a separate PLS analysis for the combined dataset and for each culture to control whether demographic variables affected the results (Keil et al. 2000). For this reason, we split the data into two subsets either for binary coded variables (e.g., gender), or multi-coded variables using the median (such as age). Results for each subset were similar to the overall results. Thus, the ratio of the demographic variables do not

pose a problem, which is why we present the findings without breaking down the samples further by gender, age, IT knowledge, etc.

Considering common method variance (CMV) in survey research, *ex ante* and *ex post* controls were implemented in order to reduce CMV. In the research design stage, the measures for the constructs were compiled from various sources *ex ante* (Chang et al. 2010). Anonymity and confidentiality of the study were also guaranteed in order to reduce the probability that respondents provided answers they believe were expected. *Ex post*, Harman's single-factor test was conducted in order to examine common method bias (Lowry and Gaskin 2014; Podsakoff et al. 2003). All items from all of the constructs were included in an unrotated exploratory factor analysis (EFA) to determine whether the majority of the variance could be ascribed to one general factor. Harman's single-factor test in this study produced 32 distinct factors, the largest of which explained only 36.82 percent of the variance of the model. This suggested that the data did not suffer from common method bias.

Structural Equation Modeling

The hypotheses were tested by analyzing the structural equation modeling. By looking at the R^2 value, which explains the variance of the respective constructs, the explanatory power of the structural equation modeling could be evaluated. In this study, as predicted by TRA and TAM, employees' intention to use is significantly influenced by their attitude toward and perceived benefits of BYOD, with an R^2 value of 0.54 for the combined dataset, 0.46 for the United States, 0.78 for Germany, and 0.35 for South Korea.

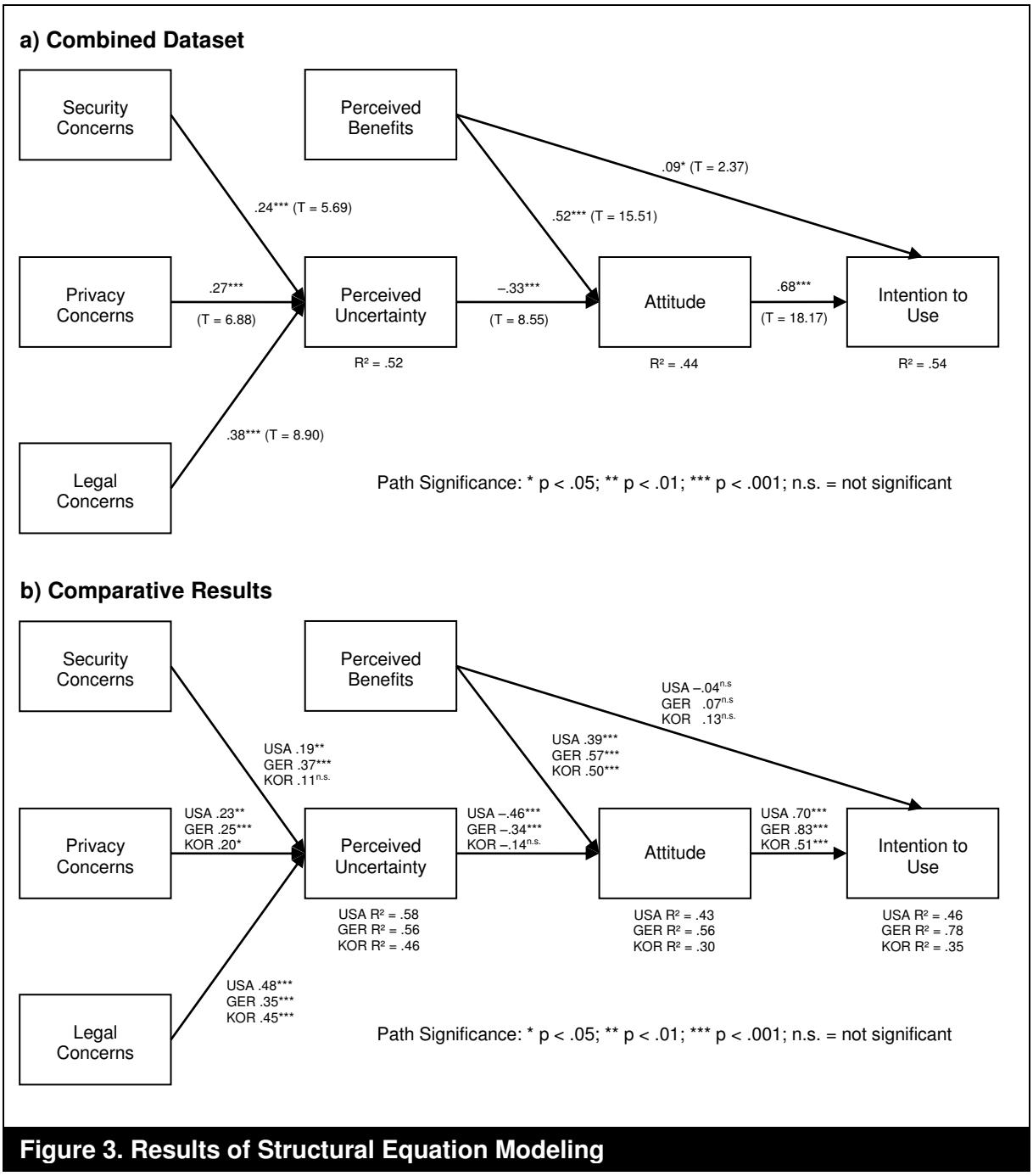

Figure 3. Results of Structural Equation Modeling

Perceived benefits have a direct significant influence on the intention to use only in the combined dataset. Both perceived benefits and perceived uncertainty significantly influence employees' attitude toward BYOD, with an R^2 value of 0.44 for the combined data set, 0.43 for the United States, 0.56 for Germany, and 0.30 for South Korea. Considering South Korea, the influence from perceived uncertainty on attitude is not significant, which is particularly

distinguishing from the United States and Germany. This study identified three classes of concerns (i.e., security, privacy, and legal concerns), which provide theoretical explanation for the antecedents of employees' perceived uncertainty toward BYOD, with an R^2 value of 0.52 for the combined data set, 0.58 for the United States, 0.56 for Germany, and 0.46 for South Korea. Figure 3a shows the results of the structural equation modeling for the combined data set, and Figure 3b the comparative results (United States, Germany, and South Korea).

The corresponding path coefficients in the structural equation modeling were statistically compared to examine hypotheses on cultural differences (see Table B2 in Appendix B for all path coefficients, t-values, and standard errors). The t-values for the differences among the United States, Germany, and South Korea have been calculated using the following formula provided by Keil et al. (2000):

$$S_{pooled} = \sqrt{\frac{N_1 - 1}{N_1 + N_2 - 2} \cdot SE_1^2 + \frac{N_2 - 1}{N_1 + N_2 - 2} \cdot SE_2^2} \qquad (1)$$

$$t = \frac{PC_1 - PC_2}{S_{pooled} \cdot \sqrt{\frac{1}{N_1} + \frac{1}{N_2}}} \qquad (2)$$

where S_{pooled} = pooled estimator for the variance

t = t-statistics with $N_1 + N_2 - 2$ degrees of freedom

N_i = sample size of dataset for culture i

SE_i = standard error of path in structural equation modeling of culture i

PC_i = path coefficient in structural equation modeling of culture i

Table 4. Statistical Testing for Differences								
	Path	**USA/GER**		**USA/KOR**		**GER/KOR**		**Results**
		S_{pooled}	**T**	S_{pooled}	**T**	S_{pooled}	**T**	
H1	ATT --> INT	.0479	–26.65***	.0723	24.76***	.0680	42.79***	Supported
H2a	BEN --> ATT	.0588	–30.06***	.0648	–15.29***	.0677	9.39***	Supported
H2b	BEN --> INT	.0406	–26.60***	.0654	–24.49***	.0670	–8.13***	Supported
H3	UNC --> ATT	.0619	–19.03***	.0687	–43.90***	.0702	–25.89***	Supported
H4a	SEC --> UNC	.0694	–25.46***	.0747	10.09***	.0718	32.92***	Supported
H4b	PRI --> UNC	.0669	–2.93**	.0819	3.45***	.0765	5.94***	Supported
H4c	LEG --> UNC	.0709	18.00***	.0901	–3.14**	.1066	–10.91***	Supported
Notes: * p < .05; ** p < .01; *** p < .001; n.s. = not significant								

The results of the statistical calculations show that all path coefficients are significantly different between the United States, Germany, and South Korea, with t-values ranging from –2.93 to –43.90, thus, all hypotheses are supported (see Table 4). The path comparison of perceived uncertainty to attitude (H3) scored the highest t-value regarding statistical differences between the United States and South Korea ($t = –43.90$, $p < 0.001$), resulting in the largest statistical difference. A closer look at the path coefficients from perceived uncertainty to attitude emphasizes this result, with a significant influence for the United States ($\beta = –0.46$, $p < 0.001$), a significant influence for Germany ($\beta = –0.34$, $p < 0.001$), and no significant influence for South Korea ($\beta = –0.14$, $p > 0.05$), which is the most distinguishing characteristic in the structural equation modeling. The second highest t-value ($t = 42.79$, $p < 0.001$) was found for Germany and South Korea regarding the path comparison of attitude to intention to use (H1). While the path coefficient from attitude to intention to use is high for Germany ($\beta = 0.83$, $p < 0.001$) as well as for the United States ($\beta = 0.70$, $p < 0.001$), the path coefficient for South Korea is medium ($\beta = 0.51$, $p < 0.001$). Relatively low t-values were found for the path comparison of privacy concerns to perceived uncertainty (H4b) for the

United States and Germany ($t = –2.93$, $p < 0.01$), the United States and South Korea ($t = 3.45$, $p < 0.001$), and for Germany and South Korea ($t = 5.94$, $p < 0.001$), with densely lying path coefficients of $\beta = 0.23$ ($p < 0.01$) for the United States, $\beta = 0.25$ ($p < 0.001$) for Germany, and $\beta = 0.20$ ($p < 0.05$) for South Korea, showing rather minor statistical differences. Considering the path comparison of security concerns to perceived uncertainty (H4a) as well as legal concerns to perceived uncertainty (H4c), the measured values of the path coefficients of the United States and South Korea lie close together with rather minor statistical differences, whereas Germany shows a rather higher path coefficient from security concerns to perceived uncertainty and a rather lower path coefficient from legal concerns to perceived uncertainty.

DISCUSSION AND IMPLICATIONS

Results of the structural equation modeling show that cultural differences can impact employees' intention to bring their own mobile devices (i.e., smartphones, tablets, and laptop computers) to work and connect them to the corporate network. We found strong support for our proposed research model, as all hypotheses were supported.

Discussion of Findings

The most significant cultural difference was found for the influence of perceived uncertainty on attitude. The United States shows the highest influence of perceived uncertainty on attitude, followed by Germany; South Korea shows no significant influence. Considering the cultural dimension of individualism and collectivism, individualist cultures like the United States and Germany pursue individual interests, whereas collectivist cultures like South Korea care more about collective interests. In terms of employees bringing their personal mobile devices to work, employees from individualist cultures evoke high concerns due to individual

interests. Mobile devices are considered to be “an expression of our personality” (Meschtscherjakov 2009, p. 1) and usually contain various information about the user’s identity. Thus, integrating a personal mobile device with all its personal information into the business environment can lead to high concerns in individualist cultures due to the ambition to protect personal information and thus individual interests. On the contrary, employees from collectivist cultures would rather prioritize collective interests such as the organization’s interest to implement BYOD above individual interests regarding the liability of loss of corporate data, possible disclosure of personal information, or risk of legal issues. Uncertainty-avoiding cultures, which are characterized with a need for precise rules, could be concerned with using personal devices for work purposes unless there are precise BOYD policies. Considering the results, the effect of individualism clearly appears to surpass the moderating effect of uncertainty avoidance on the influence of perceived uncertainty on attitude.

Individualism refers to the benefits of freedom and independence to choose any device with any operating system an employee wishes to use and which complies the most with his or her individual requirements. Collectivism, in return, describes the desire for equality and thus may endorse the preference for corporate devices with the result that every employee collectively uses the same device with the same operating system. Considering the influence of perceived benefits on attitude, other cultural factors appear to override the benefits of freedom and independence individualist employees can perceive bringing their own devices to work. American employees with their highly individualist culture, have the lowest influence of perceived benefits on attitude, followed by Korean employees, with their highly collectivist culture, and German employees, with their individualist culture and the highest influence of perceived benefits on attitude. Both Germany and South Korea are uncertainty-avoiding

cultures, which entails the need for stress and urgency that are typical characteristics of work−life blending, thus having a positive moderating effect on the influence of perceived benefits on attitude. Cultures with low uncertainty avoidance, like the United States, having a score below average, rather favor relaxed behavior, which suggests work−life balance and thus the rejection of BYOD. Work−life blending is also encouraged in masculine cultures due to the pursuit of material success rather than quality of life and thus work−life balance, which is why German participants of the survey might place more importance on BYOD benefits than Korean participants. Long-term oriented cultures also promote work−life blending due to the importance of private contacts for business needs. Indulgence and restraint might have a moderating effect on the influence of perceived benefits on attitude, because indulgent cultures place importance on leisure and would rather refuse BYOD, but simultaneously use email and the Internet more frequently for private contacts, which again supports the use of BYOD. Due to our results, we conclude that the work−life blending characteristics of uncertainty avoiding, masculine, and long-term oriented cultures prevail over moderating effects of individualism and indulgence.

With regard to the cultural dimension of power distance, our results support Hofstede et al.'s (2010) proposition that in high power distance cultures, employees are expected to be told what to do, no matter what their attitudes may be, and in low power distance cultures employees expect to be consulted. For Germany as a culture with low power distance, there lies the highest influence of attitude on behavioral intention, followed by the United States; South Korea, as a culture with higher power distance, has the lowest influence.

Implications for Research and Practice

With regard to the proposed moderating effects of the cultural dimensions, we recommend conducting further cross-cultural studies, not only taking survey items from TRA and TAM, but also including items from Hofstede et al.'s (2010) cultural dimensions theory survey instrument in order to test the proposed moderating effects. For example, the moderating effect of power distance on the influence of attitude on intention could be analyzed by surveying participants whether they would favor the idea of bringing their personal devices to work and if they would intend to do so. The moderating effect will then be tested by further surveying if they would find it important to be consulted whether BYOD should be implemented in the organization for which they are working.

The results of our study show that the employees' perceived uncertainty toward BYOD is largely due to security, privacy, and legal concerns. Here again, cultural differences exist, but regional conditions with regard to social, economic, technological, political, and legal conditions can also affect antecedents to perceived uncertainty toward BYOD. For example, considering our results, the perceived uncertainty of American employees is mainly affected by legal concerns. This may be due to the fact that legal disputes can be a big issue in the United States. Another example is that Germany is a security-sensitive country, which is supported by our results, because the perceived uncertainty of German employees is mainly affected by security concerns. In order to further investigate antecedents of perceived uncertainty toward BYOD, employees from different cultures of interest could be interviewed to reveal why they feel uncertain about bringing their own devices to work. Other relationships of the model could also be investigated by interviewing employees to gain deeper insights of employees' BYOD behavior and cultural differences.

We recommend further research to investigate the degree to which the integration of BYOD into the organization actually would increase employees' productivity and job satisfaction. Another aspect would be to examine the extent to which an integration actually would be cost-cutting for organizations, as costs may accrue, for example, due to the implementation of mobile device management software. Moreover, it would be interesting to see how the potential for employer control of employees' personal devices via mobile device management might impact the employees' perceived concerns.

The results of this study provide practical implications for organizations that are planning to implement a BYOD strategy. Organizations are dependent on employees' willingness to participate since BYOD is voluntary. Consequently, the understanding of employees' behavior is crucial for implementing BYOD strategies. If organizations plan to implement a BYOD program, employees' attitude toward BYOD must be considered, because attitude is the main driver of intention to use. Our study shows that an increase in employees' perceived benefits of bringing personal devices to work will have the greatest impact on their attitudes (see the results of the structural equation modeling for the combined dataset in Figure 3a). Considering the results for the United States (see the comparative results of the structural equation modeling in Figure 3b), perceived uncertainty has a stronger influence on attitude than perceived benefits. We suggest a diverse and cross-cultural communication for organizations to their employees when planning to implement BYOD. For cultures that place importance on perceived benefits, such as Germany and South Korea, organizations should emphasize the advantages of BYOD. For cultures that consider perceived uncertainty important, such as the United States, organizations should focus on providing a secure infrastructure that allows employees to create, store, and manage corporate data from anywhere at anytime using BYOD devices. Privacy policies and a legal framework are also

needed to minimize employees' uncertainty. In particular, uncertainty-avoiding cultures like South Korea and Germany also need precise rules, such as BYOD policies, in order to reduce ambiguity. Referring to the influence of attitude on the intention to use, especially organizations from low power distant cultures should involve employees when implementing BYOD.

Limitations and Future Research

The first limitation of our study relates to the sample used for this study, as it consists of American, German, and South Korean employees. Consequently, we control for differences only in these three cultures. Leidner and Kayworth (2006) showed that national culture significantly impacts IS studies. The results of this study can only be generalized to other cultures with caution. Our study revealed that cultural differences can be of particular importance when analyzing the employees' intention to use BYOD. Future research is needed to focus on additional cultures to either control our results by choosing similar cultures or different cultures in order to uncover new aspects. In terms of generalizability, another bias possibility is self-selection among the survey respondents (Kankanhalli et al. 2005). The topic of the questionnaire revealed that the survey was about using personal mobile devices for work purposes. Participants who responded to this survey may be those who are more likely to endorse BYOD. These participants may also tend to be less concerned about the uncertainty of bringing their own devices to work.

Considering the cultural dimensions theory, the characteristics of the cultural dimensions, the cultural scores of the countries, and the conclusions derived from the theory should be viewed as a point of reference with the presumed condition that the domestic population of a country is a homogeneous whole (Jones and Alony 2007). However, nations are considered to be

groups of ethnic units, which can be culturally different within nations (Myers and Tan 2002). This also applies to organizations in which the cultures can be distinguished from one another within nations, which is why organizations that plan to implement BYOD should refer to the cultural dimensions theory as a guiding principle with the limitation that organizational culture can be distinct from national culture. Furthermore, our assumptions for an impact of cultural differences on the intention to use BYOD relate to a deduction of propositions from the cultural dimensions theory in the BYOD context. Therefore, care must be taken when applying these assumptions due to a potential limitation in terms of comprehensiveness and adequate accuracy. Future researchers should empirically investigate the scope and preciseness of the applicability of the cultural dimensions for BYOD implementation. For this reason, qualitative research method of existential phenomenology could be conducted by performing employee interviews or focus group discussions in order to control the assumptions we presented and also identify further assumptions, which have not yet been addressed.

CONCLUSIONS AND OUTLOOK

As the importance of mobile devices has increased over the last decade, the trend of employees using their personal mobile devices for work has intensified and already begun to impact organizations. In IT consumerization, BYOD combines personal ownership and organizational use, thus several advantages and concerns for both employees and organizations come into existence. In IS research, literature on BYOD mainly addresses BYOD behavior and security issues, although the topics of BYOD in education, culture, status quo, and outcomes from BYOD also have drawn attention. Due to multifaceted characteristics of the implementation of BYOD, cultural differences are an important aspect for global organizations to have a successful implementation. This study focuses on cultural

differences of BYOD regarding employees' behavioral intention. For this reason, the cultural dimensions theory is used to compare three cultures of choice for this study: the United States (Anglo-American culture), Germany (Central European culture), and South Korea (Asian culture).

Assumptions for an impact of cultural differences on the intention to use BYOD have been derived from the cultural dimensions of power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, and indulgence. The results from structural equation modeling indicate that cultural differences among American, German, and Korean employees significantly affect the intention of bringing their own devices to work. The largest difference was found with the influence of perceived uncertainty toward BYOD on the attitude with the highest influence for the United States ($\beta = -0.46$, $p < 0.001$), the second highest influence for Germany ($\beta = -0.34$, $p < 0.001$), and no significant influence for South Korea ($\beta = -0.14$, $p > 0.05$). We conclude that this large difference is due to the fact that individualist cultures, like the United States and Germany, pursue individual interests and therefore are more concerned about security, privacy, and legal issues that could harm the individual self, compared to collectivist cultures like South Korea, which place more importance on collective interests. Further differences are identified in this study and discussed for cross-cultural comparisons. With regard to BYOD behavior and security issues, three classes of concerns that significantly impact employees' intention to use BYOD are recognized in this study. Hence, a secure infrastructure (along with network, application, and device security), privacy policies, and a legal framework are needed for organizations that plan to implement BYOD, particularly organizations from individualist cultures, in order to reduce uncertainty.

In the course of IT consumerization, employees and organizations can improve productivity, flexibility, and job satisfaction by allowing them to choose the best devices for their needs. BYOD policies can be focused. "Choose your own device" (CYOD) may follow the BYOD lead, allowing employees to choose an organization-owned device for work purposes. Recently on the scene, the corporate-owned, personally enabled (COPE) strategy lets employees choose a company-owned device and use their own apps as well as corporate apps on the device. Although BYOD, CYOD, and COPE vary in terms of cost sharing, they share the fundamental principles, such as security implications (Absalom 2014).

Our study highlights several implications for future research as well as for practitioners. Due to the ongoing discussion of the BYOD phenomenon, we expect a continuing increase in the theoretical and practical importance of the topic. Furthermore, we anticipate a discussion of cultural challenges of BYOD regarding several aspects, such as considerations of work−life balance and work−life blending, values of freedom and equality, the pursuit of material success and quality of life, and reflections on urgency and leisure time.

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APPENDIX A: SURVEY DETAILS

Table A1. Survey Instrument

Items	English	German	Korean
Security Concerns (SEC), Sources: Pavlou et al. 2007			
	If I would use my personal mobile device to create, store and manage sensitive corporate data...	Wenn ich mein persönliches mobiles Endgerät für das Erstellen, Speichern und Verwalten von sensiblen Unternehmensdaten nutzen würde…	만일 나의 개인 모바일기기로 회사의 중요한/민감한 자료를 처리/다룬다면 (저장, 관리등)…
SEC1	I would be concerned that data could be lost, for example, data theft, loss of device, etc.	wäre ich besorgt, dass Daten verloren gehen könnten, z. B. durch Datendiebstahl, Verlust des Gerätes usw.	자료 손실, 자료도난, 기기의 분실에 걱정된다고 생각한다.
SEC2	the security issue would distress me.	würde der Sicherheitsaspekt mir Sorgen bereiten.	보안이슈가 나를 괴롭히게 한다.
SEC3	I would feel insecure.	würde ich mich unsicher fühlen.	불안을 느끼게 한다.
SEC4	data would be exposed to threats to information security.	wären die Daten Risiken der Informationssicherheit ausgesetzt.	자료가 정보보안의 위협에 노출되리라 생각한다.
Privacy Concerns (PRI), Sources: Pavlou et al. 2007			
	If I would use my personal mobile device to create, store and manage sensitive corporate data...	Wenn ich mein persönliches mobiles Endgerät für das Erstellen, Speichern und Verwalten von sensiblen Unternehmensdaten nutzen würde…	만일 나의 개인 모바일기기로 회사의 중요한/민감한 자료를 처리/다룬다면 (저장, 관리등)…
PRI1	I would be concerned that my employer is collecting too much information about me, for example,	wäre ich besorgt, dass mein Arbeitgeber zu viele Informationen über mich erfasst, z. B. Profile auf	나의 고용주가 나의 개인 이멜, 사진, 소셜넷워크등에 관한 정보수집을 하리라 걱정된다.

	profiles of social networks, personal emails, personal photos, etc.	sozialen Netzwerken, persönliche E-Mails, persönliche Fotos usw.	
PRI2	I would be concerned about my privacy.	wäre ich über meine Privatsphäre besorgt.	나의 비밀(프라이버시)에 걱정된다.
PRI3	my personal information could be misused.	könnten meine persönlichen Informationen missbraucht werden.	나의 개인정보가 오용되리라 생각한다.
PRI4	I would have doubts as to how well my privacy is protected.	hätte ich meine Zweifel, ob meine Privatsphäre geschützt ist.	나의 비밀(프라이버시)를 어떻게 보호해야 할지 생각해본다.
PRI5	it would bother me that my employer could scan my personal data.	würde es mich stören, wenn mein Arbeitgeber persönliche Informationen abfragen könnte.	나의 고용주가 내 개인자료를 스캔할수도 있음에 괴롭히게 한다.
PRI6	my personal information could be accessed by unknown parties.	könnten sich unbekannte Dritte Zugang zu meinen persönlichen Informationen verschaffen.	나의 개인정보가 모르는 삼자에게 접근될수도 있다.
Legal Concerns (LEG), Sources: Self-developed			
	If I would use my personal mobile device to create, store and manage sensitive corporate data...	Wenn ich mein persönliches mobiles Endgerät für das Erstellen, Speichern und Verwalten von sensiblen Unternehmensdaten nutzen würde…	만일 나의 개인 모바일기기로 회사의 중요한/민감한 자료를 처리/다룬다면 (저장, 관리등)…
LEG1	I would be concerned that legal conflicts could emerge, for example, work time regulation, account of charges, commitment to maintenance, etc.	wäre ich besorgt, dass rechtliche Konflikte entstehen könnten, z. B. Arbeitszeitregelung, Kostenabrechnung, Wartungsverpflichtung usw.	작업시간 규제등 법적인 문제가 발생할수도 있다고 걱정된다.
LEG2	it would bother me that my employer could assert a legal claim against me.	würde es mich stören, dass mein Arbeitgeber Rechtsansprüche gegen mich geltend machen könnte.	나의 고용주가 나에 대해 법적대응을 할 수 있다고 나를 괴롭힌다.
LEG3	I would be concerned about legal aspects.	wäre ich über rechtliche Aspekte besorgt.	법적인측면에 걱정한다.
LEG4	I would have doubts as to how well my legal position is protected.	hätte ich meine Zweifel, ob meine rechtliche Situation geschützt ist.	나의 법적으로 어떻게 보호할지에 대해 걱정한다.
Perceived Uncertainty (UNC), Sources: Pavlou et al. 2007			
	I believe that using my personal mobile device for work purposes would...	Ich denke, dass die Nutzung meines persönlichen mobilen Endgeräts für berufliche Zwecke...	직무를 하는데, 나의 개인 모바일 기기를 사용함이...
UNC1	involve a high degree of uncertainty (personal and/or work related).	einen hohen Grad an Unsicherheit mit sich bringen würde (persönlich und/oder beruflich).	직무와 개인일로써, 고도의 불확실성이 있다고 본다.
UNC2	fill me with concerns (personal and/or work related).	mich im Allgemeinen mit Sorge erfüllen würde (persönlich und/oder beruflich).	직무와 개인일로써, 걱정이 된다.
UNC3	be questionable (personal and/or work related).	bedenklich wäre (persönlich und/oder beruflich).	직무와 개인일로써, 의심이 된다.
UNC4	expose me to many uncertainties (personal and/or work related).	mich vielen Unsicherheiten aussetzen würde (persönlich und/oder beruflich).	직무와 개인일로써, 불확실성이 개연된다.
Perceived Benefits (BEN), Sources: Davis 1989			
	Using my personal mobile device for work purposes would...	Mein persönliches mobiles Endgerät für berufliche Zwecke zu nutzen würde...	직장일을 하는데 개인 모바일 기기사용이...
BEN1	enable me to accomplish my tasks more quickly.	es mir ermöglichen, meine Aufgaben schneller zu erledigen.	나의 업무를 빨리 마치게 한다.
BEN2	improve my job performance.	meine Arbeitsleistung verbessern.	나의 직무성과를 개선한다.
BEN3	increase my productivity.	meine Produktivität erhöhen.	나의 생산성를 제고한다.
BEN4	enhance my effectiveness on the job.	meine Leistungsfähigkeit steigern.	직무효과를 증진한다.
BEN5	make it easier for me to do my job.	es mir erleichtern, meine Aufgaben zu erledigen.	직무를 하는데, 쉬워진다.
Attitude (ATT), Sources: Nysveen et al. 2005; Taylor and Todd 1995			
	Using my personal mobile device for work purposes...	Mein persönliches mobiles Endgerät für berufliche Zwecke zu nutzen…	직무를 하는데, 나의 개인 모바일 기기를 사용함이...
ATT1	is a good idea.	ist eine gute Idee.	좋은 생각이다.
ATT2	is a wise idea.	ist eine kluge Idee.	현명한 생각이다.
ATT3	would be positive.	wäre positiv.	긍정적이다.
ATT4	would be beneficial.	wäre vorteilhaft.	혜택을 볼 수 있다.

ATT5	would be favorable.	wäre angenehm.	우호적이다.
ATT6	I like the idea of using my personal mobile device for work purposes.	Mir gefällt die Vorstellung, mein persönliches mobiles Endgerät für berufliche Zwecke zu nutzen.	직무를 하는데, 나의 개인 모바일 기기 사용하는 아이디어를 나는 좋아한다.
Intention to Use (INT), Sources: Venkatesh and Davis 1996; Oliver and Bearden 1985			
INT1	Assuming I have my employer's permission, I would use my personal mobile device for work purposes.	Angenommen ich hätte die Erlaubnis von meinem Arbeitgeber, würde ich mein persönliches mobiles Endgerät für berufliche Zwecke nutzen.	나의 고용주의 허락을 받는다고 가정할 경우, 나는 직무를 위해, 나의 개인 모바일 기기를 사용하고저 한다.
INT2	Given that I have my employer's permission to use my personal mobile device for work purposes, I predict that I would use it.	Sollte mein Arbeitgeber mir die Erlaubnis zur Nutzung meines persönlichen mobilen Endgerätes für berufliche Zwecke erteilen, würde ich dies wahrnehmen.	나의 고용주의 허락을 받았다고 할 경우, 나는 직무를 위해, 나의 개인 모바일 기기를 사용할것 같다 (예측한다)
INT3	How probable is it that you would use your personal mobile device for work purposes, assuming that you have your employer's permission?	Wie wahrscheinlich ist es, dass Sie Ihr persönliches mobiles Endgerät für berufliche Zwecke nutzen würden, wenn Sie die Erlaubnis Ihres Arbeitgebers hätten?	나의 고용주의 허락을 받는다고 가정할 경우, 나는 직무를 위해, 나의 개인 모바일 기기를 얼마나 사용하리라 생각하는가?

Table A2. Profiles of Responding Participants

	USA (N=210)		GER (N=178)		KOR (N=154)		ALL (N=542)	
Gender								
Male	54	25.7%	101	56.7%	122	79.2%	277	51.1%
Female	137	65.2%	57	32.0%	31	20.1%	225	41.5%
Not specified	19	9.0%	20	11.2%	1	0.6%	40	7.4%
Age								
≤ 19	0	0.0%	0	0.0%	0	0.0%	0	0.0%
20-29	108	51.4%	101	56.7%	13	8.4%	222	41.0%
30-39	38	18.1%	34	19.1%	60	39.0%	132	24.4%
40-49	29	13.8%	17	9.6%	54	35.1%	100	18.5%
50-59	12	5.7%	5	2.8%	25	16.2%	42	7.7%
≥ 60	4	1.9%	1	0.6%	2	1.3%	7	1.3%
Not specified	19	9.0%	20	11.2%	0	0.0%	39	7.2%
Participants' knowledge of computers and IT								
1 (Very low)	5	2.4%	8	4.5%	1	0.6%	14	2.6%
2	16	7.6%	9	5.1%	1	0.6%	26	4.8%
3	16	7.6%	8	4.5%	14	9.1%	38	7.0%
4	113	53.8%	67	37.6%	89	57.8%	269	49.6%
5 (Very high)	41	19.5%	66	37.1%	47	30.5%	154	28.4%
Not specified	19	9.0%	20	11.2%	2	1.3%	41	7.6%
Size of the organization (# of employees)								
≤ 9	24	11.4%	6	3.4%	5	3.2%	35	6.5%
10-49	46	21.9%	30	16.9%	23	14.9%	99	18.3%
50-249	29	13.8%	22	12.4%	42	27.3%	93	17.2%
250-499	20	9.5%	19	10.7%	16	10.4%	55	10.1%
500-999	10	4.8%	11	6.2%	15	9.7%	36	6.6%
≥ 1000	62	29.5%	70	39.3%	53	34.4%	185	34.1%
Not specified	19	9.0%	20	11.2%	0	0.0%	39	7.2%
Industry								
Education	13	6.2%	23	12.9%	14	9.1%	50	9.2%
Financial Services	9	4.3%	9	5.1%	9	5.8%	27	5.0%
Government	8	3.8%	3	1.7%	19	12.3%	30	5.5%
Food/Beverage/CPG	12	5.7%	2	1.1%	1	0.6%	15	2.8%
Health Care	20	9.5%	11	6.2%	1	0.6%	32	5.9%

Manufacturing	5	2.4%	14	7.9%	43	27.9%	62	11.4%
Nonprofit	13	6.2%	3	1.7%	10	6.5%	26	4.8%
Medical, Bio-Technology, Pharmacology	5	2.4%	5	2.8%	0	0.0%	10	1.8%
Real Estate	4	1.9%	0	0.0%	1	0.6%	5	0.9%
Services	13	6.2%	23	12.9%	18	11.7%	54	10.0%
Information Technology	18	8.6%	46	25.8%	16	10.4%	80	14.8%
Telecommunications	6	2.9%	2	1.1%	0	0.0%	8	1.5%
Travel	1	0.5%	3	1.7%	0	0.0%	4	0.7%
Wholesale/Retail	10	4.8%	3	1.7%	3	1.9%	16	3.0%
Other	54	25.7%	11	6.2%	18	11.7%	83	15.3%
Not specified	19	9.0%	20	11.2%	1	0.6%	40	7.4%
Information sensitivity of the organization								
1 (Very low information sensitivity)	6	2.9%	0	0.0%	0	0.0%	6	1.1%
2	34	16.2%	24	13.5%	25	16.2%	83	15.3%
3	21	10.0%	20	11.2%	22	14.3%	63	11.6%
4	82	39.0%	48	27.0%	85	55.2%	215	39.7%
5 (Very high information sensitivity)	48	22.9%	66	37.1%	22	14.3%	136	25.1%
Not specified	19	9.0%	20	11.2%	0	0.0%	39	7.2%
Do you have the permission by your organization to use your personal mobile device for work purposes?								
Yes	114	54.3%	56	31.5%	74	48.1%	244	45.0%
No	78	37.1%	104	58.4%	80	51.9%	262	48.3%
Not specified	18	8.6%	18	10.1%	0	0.0%	36	6.6%

APPENDIX B: STATISTICAL DETAILS

Table B1. Loadings and Cross Loadings of Measures

	SEC	PRI	LEG	UNC	BEN	ATT	INT
SEC1	**.78**	.31	.26	.36	–.09	–.18	–.19
SEC2	**.89**	.34	.32	.41	–.18	–.23	–.27
SEC3	**.86**	.36	.33	.46	–.21	–.28	–.31
SEC4	**.84**	.34	.33	.42	–.18	–.23	–.22
PRI1	.33	**.89**	.51	.52	–.02	–.20	–.23
PRI2	.33	**.90**	.48	.53	.00	–.22	–.25
PRI3	.38	**.91**	.51	.53	–.05	–.22	–.19
PRI4	.38	**.90**	.47	.54	–.06	–.21	–.22
PRI5	.26	**.68**	.56	.43	–.12	–.27	–.21
PRI6	.34	**.80**	.47	.48	–.02	–.16	–.15
LEG1	.31	.50	**.81**	.58	–.06	–.18	–.17
LEG2	.25	.41	**.80**	.41	–.08	–.20	–.18
LEG3	.34	.56	**.93**	.60	–.02	–.21	–.22
LEG4	.36	.55	**.92**	.59	–.02	–.19	–.21
UNC1	.44	.54	.56	**.90**	–.15	–.37	–.36

UNC2	.46	.55	.57	**.93**	–.16	–.38	–.37
UNC3	.46	.56	.60	**.93**	–.18	–.42	–.37
UNC4	.45	.54	.59	**.92**	–.13	–.36	–.33
BEN1	–.22	–.07	–.07	–.20	**.90**	.53	.46
BEN2	–.17	–.05	–.06	–.16	**.93**	.55	.44
BEN3	–.12	–.01	.00	–.10	**.92**	.51	.42
BEN4	–.21	–.03	–.06	–.14	**.91**	.52	.44
BEN5	–.20	–.07	–.03	–.17	**.89**	.51	.43
ATT1	–.24	–.23	–.19	–.39	.52	**.92**	.65
ATT2	–.23	–.20	–.23	–.37	.53	**.90**	.62
ATT3	–.25	–.20	–.18	–.35	.53	**.92**	.65
ATT4	–.19	–.15	–.12	–.28	.53	**.85**	.59
ATT5	–.24	–.27	–.21	–.40	.50	**.89**	.64
ATT6	–.31	–.28	–.25	–.42	.48	**.85**	.75
INT1	–.27	–.23	–.21	–.37	.45	.68	**.95**
INT2	–.28	–.22	–.22	–.35	.44	.66	**.95**
INT3	–.28	–.23	–.21	–.37	.47	.72	**.91**

Notes: SEC = security concerns, PRI = privacy concerns, LEG = legal concerns, UNC = perceived uncertainty, BEN = perceived benefits, ATT = attitude, INT = intention to use

Table B2. Statistical Comparison of Hypothesized Paths

	United States (N=210)			**Germany (N=178)**			**South Korea (N=154)**		
Path	**β**	**T**	**SE**	**β**	**T**	**SE**	**β**	**T**	**SE**
ATT --> INT	.70***	12.72	.0548	.83***	21.86	.0381	.51***	5.64	.0910
BEN --> ATT	.39***	6.61	.0596	.57***	9.89	.0578	.50***	6.50	.0776
BEN --> INT	–.04$^{n.s.}$	0.89	.0410	.07$^{n.s.}$	1.78	.0401	.13$^{n.s.}$	1.48	.0885
UNC --> ATT	–.46***	7.57	.0611	–.34***	5.48	.0628	–.14$^{n.s.}$	1.82	.0779
SEC --> UNC	.19**	2.69	.0722	.37***	5.63	.0659	.11$^{n.s.}$	1.44	.0780
PRI --> UNC	.23**	3.13	.0730	.25***	4.30	.0589	.20*	2.16	.0927
LEG --> UNC	.48***	6.05	.0787	.35***	5.86	.0604	.45***	4.31	.1037

Notes: * p < .05; ** p < .01; *** p < .001; n.s. = not significant

Appendix 3: Mobile Applications and Access to Personal Information: A Discussion of Users' Privacy Concerns

Authors: Kenan Degirmenci, Nadine Guhr, Michael H. Breitner

Presenting Author: Kenan Degirmenci

In: Proceedings of the 34th International Conference on Information Systems (ICIS), December 15-18, 2013, Milan, Italy.

Link: http://aisel.aisnet.org/icis2013/proceedings/SecurityOfIS/6/

Abstract: Mobile applications (apps) have become highly popular and are creating new economic opportunities for app providers, developers, software companies, and advertisers. Due to the access to personal information, mobile apps may pose a threat to users' privacy, which can incite users not to install or to uninstall mobile apps. In the last twenty years, concerns for information privacy (CFIP) have been investigated by several studies, which adapted CFIP to an online and to a mobile context. Our extended approach for mobile users' information privacy concerns (MUIPC) analyzes four dimensions of access to personal information, i.e., personal identity, location, device content, and system and network settings. By conducting an online survey with 474 participants, we test the influence of these dimensions on MUIPC with a structural equation model (SEM). Three dimensions are found to be significantly influential. The results are discussed and implications for research and practice are given.

Appendix 4: How Can Mobile Applications Reduce Energy Consumption? An Experimental Investigation of Electric Vehicles

Authors: Kenan Degirmenci, Torben M. Katolla, Michael H. Breitner

Presenting Author: Kenan Degirmenci

In: Proceedings of the 23rd European Conference on Information Systems (ECIS), May 26-29, 2015, Münster, Germany.

Link: http://aisel.aisnet.org/ecis2015_cr/36/

Abstract: The role of information systems for environmental sustainability has received considerable attention over the last several years. In view of global warming and climate change, a transition from combustion to electric vehicles (EVs) can help reduce greenhouse gas (GHG) emissions. Since sustainable behavior often lacks relevant information about its environmental effects, the role of information systems in influencing energy consumption is being explored in this paper. The main focus is to investigate the impact of driver assistance systems in form of mobile applications on the energy consumption of EVs. To test such an impact, a field experiment is conducted by defining a control group and an experimental group. Test drives are performed with an all-electric, lithium-ion battery powered, small passenger city car. As the treatment of the study, a mobile application is chosen that monitors excessive acceleration and hard braking. The results reveal significant differences among the groups, which indicate that using smartphone-based driver assistance systems significantly reduces the energy consumption of EVs. This can entail several benefits, including an increase of range of EVs, electricity cost savings, decrease of vehicle wear, and reduction of GHG emissions. The findings are discussed and implications for research and practice are given.

Appendix 5: Market Introduction of Electric Cars: A SWOT Analysis

Authors: Thomas Völk, Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #63, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, July 11, 2014.

Abstract: This paper investigates potential strategies for a car manufacture corporation in a market introduction stage of electric cars. A SWOT analysis is conducted on the example of the Volkswagen Group, examining strengths and weaknesses of the company, as well as opportunities and threats in the environment of the company. Regarding the analysis of the opportunities and threats, the PESTLE approach is used, i.e., the analysis of political, economic, social, technological, legal, and environmental segments. Several strategies are presented.

Appendix 6: Elektromobilität in Deutschland und anderen Ländern: Vergleich von Akzeptanz und Verbreitung[17]

Authors: Raphael Kaut, Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #68, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, September 29, 2015.

Abstract: Aufgrund des voranschreitenden Klimawandels und der immer größer werdenden Belastung durch die CO_2-Emissionen müssen Maßnahmen getroffen werden, um die Umwelt zu schonen. Da der Verkehrssektor für einen großen Anteil der CO_2-Abgase verantwortlich ist, ist ein Wandel zu alternativen Antriebskonzepten in diesem Bereich unausweichlich. Ein möglicher Weg für diesen Wandel ist der Umstieg auf Elektromobilität. Während die Verbreitung von Elektrofahrzeugen in Ländern wie Japan, Norwegen oder den USA verhältnismäßig hoch ist und stetig ansteigt, verläuft die Entwicklung in Deutschland bislang eher schleppend. Obwohl die Bundesrepublik eines der führenden Automobilländer weltweit darstellt, ist die nationale Akzeptanz für elektrisch angetriebene Autos sehr gering. Mit Hilfe dieser Arbeit soll daher ein Vergleich des Elektromobilitätsmarktes in Deutschland und anderen Ländern vorgenommen werden, um mögliche Gründe für die unterschiedliche Resonanz innerhalb der Bevölkerungen zu erarbeiten. Dabei wird auf unterschiedliche Aspekte wie beispielsweise die Stromproduktion, staatliche Förderungen oder die Rolle der Automobilhersteller eingegangen. Darüber hinaus wird eine Nutzerumfrage durchgeführt, um einen Eindruck über die Haltung der deutschen Bevölkerung gegenüber der Thematik zu bekommen und weitere Faktoren, die für die geringe Verbreitung der Elektrofahrzeuge verantwortlich sein könnten, zu ermitteln. Letztendlich werden daraus Lösungsansätze zur Erweiterung der Akzeptanz für die Elektromobilität abgeleitet und dementsprechend Handlungsempfehlungen für die unterschiedlichen einflussnehmenden Teilnehmer formuliert.

[17] This discussion paper is a reprint of the bachelor thesis of Raphael Kaut, which was supervised by Kenan Degirmenci.

Appendix 7: Carsharing: A Literature Review and a Perspective for Information Systems Research

Authors: Kenan Degirmenci, Michael H. Breitner

Presenting Author: Kenan Degirmenci

In: Proceedings of the Multikonferenz Wirtschaftsinformatik (MKWI), February 26-28, 2014, Paderborn, Germany, pp. 962-979.

Link: http://rambaldo.uni-paderborn.de/indico/contributionDisplay.py?contribId=42&sessionId=109&confId=0

Abstract: Private car ownership in the context of the ongoing urbanization is creating challenges concerning environmental pollution, high energy costs, and limited and expensive parking. As a reaction to these negative impacts, companies are developing new mobility alternatives to private car ownership. One alternative is carsharing that provides individuals with cars from a fleet on an as-needed basis. To create a conceptual structuring of the topic of carsharing, we conduct a literature review identifying 93 articles and six concepts, i.e., market analysis, location, travel behavior, information systems, electric carsharing, and sustainability. Findings are discussed and implications for information systems research are given.

Appendix 8: A Systematic Literature Review of Carsharing Research: Concepts and Critical Success Factors

Authors: Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #69, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, September 29, 2015.

Abstract: This paper aims to examine critical success factors of carsharing services by conducting a literature review. In order to give an overview of existing carsharing research articles, a conceptual structuring of the topic of carsharing is created. Hereby, 130 articles are analyzed, identifying 6 key concepts, i.e., market analysis, location, travel behavior, information systems, electric carsharing, and sustainability. With regard to the defined parameters of the literature review, the concept of market analysis reveals the strongest interest in carsharing research counting approximately half of the reviewed literature. However, the other concepts have received considerable attention in the past few years, which is why the interdisciplinarity level of carsharing research has grown substantially. Since carsharing is a growing trend in practice as well as in research, we analyze the background characteristics associated with the growth and success of carsharing services by deriving critical success factors from the literature. The critical success factors are discussed for practical implications and recommendations for further research are given.

Appendix 9: Gemeinschaftsgefühl und Motivationshintergrund: Eine qualitative Inhaltsanalyse im Bereich des Elektro-Carsharing[18]

Authors: Mina Baburi, Katrin Günther, Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #65, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, November 18, 2014.

[18] This discussion paper is a reprint of the bachelor thesis of Mina Baburi and Katrin Günther, which was supervised by Kenan Degirmenci.

Appendix 10: Analyzing the Impact of Drivers' Experience with Electric Vehicles on the Intention to Use Electric Carsharing: A Qualitative Approach

Authors: Mareike Thiessen, Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #66, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, December 2, 2014.

Appendix 11: Ein Smartphone-Bonussystem zum energieeffizienten Fahren von Carsharing-Elektrofahrzeugen

Authors: Maximilian Kreutz, Phillip Lüpke, Kathrin Kühne, Kenan Degirmenci, Michael H. Breitner

In: IWI Discussion Paper #71, Institut für Wirtschaftsinformatik, Leibniz Universität Hannover, December 9, 2015.

Abstract: Carsharing mit Elektrofahrzeugen wird heute bereits von vielen Anbietern betrieben. Die langen Ladezeiten der Batterie führen jedoch dazu, dass das Fahrzeug nicht sofort vom nächsten Kunden genutzt werden kann. Um diesem Problem entgegenzuwirken, ist die Einführung eines Bonussystems zur Förderung energieeffizienten Fahrens von großer Bedeutung und kann unterstützen, diese Standzeiten zu reduzieren. Im Rahmen dieser Arbeit wird ein Smartphone-Bonussystem konzipiert und diskutiert. Das entwickelte Bonussystem gibt einen ersten Einblick, wie eine Smartphone-App aufgebaut sein könnte, um Nutzern von Carsharing-Elektrofahrzeugen zu motivieren, energieeffizienter zu fahren. Die Anreize dafür sind extrinsischer Art und werden materiell ausgestaltet. Zum einen repräsentiert ein Daumen die Fahrweise eines Carsharing-Nutzers und appelliert dabei mit einer grünen Farbe an die nicht-monetären Anreize. Zum anderen können monetäre Anreize, wie bspw. Rabatte, eine energieeffiziente Fahrweise unterstützen. Somit ergeben sich eine Erhöhung der Reichweite der Elektrofahrzeuge, eine Reduzierung der Stromkosten und eine Senkung des Fahrzeugverschleißes für die Carsharing-Unternehmen.

Appendix 12: Mobile Infotainment – IT Solutions for Cruise Ships

Authors: Christian Krause, Kenan Degirmenci

In: Cruise Management – Information and Decision Support Systems, A. Papathanassis, M. H. Breitner, C. Schön, N. Guhr (eds.), Wiesbaden: Gabler, 2012, pp. 185-203.

Link: http://www.springer.com/book/9783834932723