DRIVERS FOR THE ADOPTION OF MOBILE DEVICE MANAGEMENT IN ORGANIZATIONS

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Abstract

The diffusion of mobile devices rapidly increased in the last decade. Nowadays, smartphones are part of our daily lives, both with respect to private and professional use. This leads to several challenges for enterprises, like the trend to "Bring Your Own Device" or IT consumerization. IT executives are forced to ensure a high level of security, provide services for employees and support the enterprise productivity. In this context, several software solutions have been introduced to manage the mobile IT, one of which are mobile device management (MDM) systems. However, until now, there is a lack of research concerning possible factors that may influence the adoption of MDM systems in enterprises. Based on the well-established Technology Organization Environment (TOE) Framework a model for MDM adoption in enterprises is constructed and tested using partial least squares structural equation modelling (PLS-SEM). Data was gathered by means of an online survey, in which 95 IT executives from German enterprises participated. Overall, it could be found that perceived security benefits, costs, firm-size, and the BYOD culture significantly influence MDM adoption, while regulations, business partners, employees' innovativeness with IT and the amount of mobile device usage have no significant influence.

Keywords: IT-adoption, TOE, Mobile Device Management, IT-Management

1   Introduction

The rapid technological development of mobile devices and the mobile infrastructure, as well as the usage of mobile applications, has a big impact on businesses. According to Accenture's 'Mobile-Web-Watch 2012' survey, 20% of all smartphone mobile usage is of business nature (Mohr et al., 2012). It seems that the functionality of such devices and applications has improved to a point where people like to use them professionally and enterprises force their diffusion among the employees. Moreover, novel trends like Bring You Own Device (BYOD) and IT Consumerization additionally challenge enterprises managing their transformation process into a mobile enterprise (Harris et al. 2012a, Weiß and Leimeister, 2013). On the one hand, this trends offer new potentials for enterprises to create business values, e.g. by saving IT expenditures or by an increased efficiency and satisfaction of employees (Stieglitz and Brockmann, 2012). On the other hand, enterprises are challenged as new security concepts are required and the integration into the existing IT landscape has to be managed (Lebek et al., 2013).

One appropriate solution provided by software vendors are mobile device management (MDM) systems (The Enterprise Mobile Foundation, 2011). MDM systems offer a number of functions that specifically target the management of mobile devices (Kersten and Kettler, 2012; Humme 2013). In detail, mobile device management systems offer functions such as remote device administration and configuration, inventory and asset management, remote-wipe or device lockout, installation of updates

on operating system or application level, geolocation of devices, or cost management (Humme, 2013; Basso and Redmann, 2012; Hemker, 2012).

According to IDC (2012), the market for solution providers in this segment will increase from US$ 444.6m in 2011 to US $1.8bn in 2016. Furthermore, 70% of enterprises plan to increase their budget for enterprise mobile management solutions, within the next 24 months (Crook et al., 2012). The developments in this area show that many companies around the world have already recognized the importance of mobile devices and applications for employee productivity and taken strategic measures to introduce and use them (Kietzmann et al., 2013).

Considering the arguments above, it can be stated that MDM is of growing relevance for enterprises. However, until now, there is a lack of research investigating which factors influence the adoption of mobile device management systems within enterprises. In our study we seek to contribute to this field by conducting a survey amongst IT executives employed in 95 companies.

The paper proceeds as follows: First, we provide an overview of current research on mobile devices in enterprises as well as on mobile device management. In a next step, we provide an extensive overview of the Technology Organization Environment (TOE) Framework research in the last decades. Then, we derive possible organizational, environmental and technological influence factors for MDM adoption and formulate nine hypotheses. Afterwards, we describe the methodology and the statistical analysis (PLS-SEM) followed by the results of our study. Finally we discuss the findings, limitations and provide an outlook for future research in this field.

2 Related Work

2.1 Mobile Devices in Enterprises

The diffusion of mobile devices such as feature phones and Personal Digital Assistants (PDAs) started in the early 1990s and proceeded quickly in the following decades (Wiredu, 2007). The launch of the Apple iPhone in 2007 introduced the concept of mobile applications (apps) and opened up new potentials for the use of smartphones. Research in the field of mobile devices nowadays covers a multiplicity of research areas such as security of mobile applications and devices or the design and development of mobile applications (Chandra et al., 2010; Markova et al., 2007; Penttinen et al., 2010; Steele and Tao, 2006). Furthermore, some studies have specifically evaluated the mobile technologies for business purposes (Chandra et al., 2010; Markova et al., 2007; Penttinen et al., 2010; Steele and Tao, 2006). Generally, it can be stated that mobile devices, especially smartphones, have already massively influenced business as well as private life (Ahuja et al., 2007; Schadler and McCarthy, 2012; Willis, 2012) leading to several challenges and opportunities for organizations as well as for employees (Golden and Geisler, 2007; Harris et al., 2012b). In order to satisfy the needs of their employees and to keep or improve their business values organizations need to develop a "mobile strategy". Beyond this it might be necessary to manage the transformation process into a so-called "*mobile enterprise*". This term describes the ideal of a company that comprehensively integrates mobile devices such as smartphones or tablets into their business processes (Stieglitz and Brockmann, 2012; Dery and MacCormick, 2012).

The primary goal for organizations is to ensure organizational performance including productivity and profitability, inventory, competitive advantage, and costs (Melville et al., 2004). Stieglitz and Brockmann (2012) state in their work, that organizational performance can be achieved by using mobile IT, if a well-designed company-wide strategy is established, which addresses technical and organizational issues. As other studies show, the variety of available device manufacturers and the multiplicity of operating systems lead to more and more heterogeneous mobile IT landscapes (Weiß and Leimeister, 2012). Moreover, the observable trends towards IT-consumerization, such as the use of private mobile devices for business purposes as well as the "bring your own device" (BYOD)

culture increase the complexity of mobile IT (Niehaves et al., 2012; Harris et al., 2012a). Both, BYOD and the heterogeneous IT landscape sorrows novel challenges for the IT department. Managing mobile IT becomes an increasingly complex task and necessitates specific software and new IT management strategies (Weiß and Leimeister, 2013). One raising software solution assisting IT departments in solving these problems are Mobile Device Management systems. They offer functionalities to manage mobile devices, applications and enforce compliance regulations (Humme, 2013; Basso and Redmann, 2012; Hemker, 2012).

2.2   Mobile Device Management

The developments and challenges described above illustrate that enterprises need to manage the use of mobile devices and applications. Software developers have responded to this need and offer enterprise mobility management (EMM) solutions, subsuming software supporting BYOD (e.g. containerization), mobile security, mobile application management (MAM) and mobile device management (MDM) (Steele, 2013a, 2013b; Winthrop, 2011). Nowadays a multiplicity of mobile device management vendors exists. Gartner (2013) classified the solutions "Air-Watch", "Mobile Iron" and "Citrix" as the leading vendors in the MDM market (Redmann et al., 2013). However, no clear distinction between the different types of enterprise mobility management (EMM) software exists. One approach differentiates between mobile device management as a full service approach and mobile application management, offering the possibility to manage and secure particular apps (Steele, 2013a; Hemker, 2012). In practice, the application management is often either integrated or an extension of the MDM (Winthrop, 2011; Finneran, 2011). According to Winthrop (2011) and Finneran (2001) we understand MDM as the umbrella term subsuming MAM functions. In this article, we refer to the following definition of MDM by Beimborn and Palitza (2013): "MDM supports centralized control of an entire fleet of mobile devices (smartphones and tablets) and mobile applications by applying and ensuring pre-defined configuration settings".

Current research activities focus mainly on technical specifications to enhance the security level of MDM-Solutions (Keunwoo et al., 2013; Joon-Myung et al., 2009). For instance Joon-Myung et al. (2009) developed a method to remotely determine and correct software problems of mobile devices. Their prototype is based on the Open Mobile Alliance (OMA) device management (DM), the *de-facto* standard for mobile device management, developed from academia and industry (Salvatore, 2013; Joon-Myung et al., 2009). Keunwoo et al. (2013) suggested another approach and analysed and identified threat agents, assets, and adverse action to extract security requirements such as a protection profile. Their research resulted in a design for a secure MDM system.

Besides security, enterprise application management could be identified as a major field of research (Hess et al., 2012; Wenzel et al., 2013; Beimborn and Palitza, 2013). Beimborn and Palitza (2013) developed a framework which serves as foundation for the conceptualization and explicit values for enterprises, users, and app-developers. Overall, they found that enterprise application services reduces shadow-IT, allows effective and efficient app life cycle management and reduces the total cost of ownership of enterprise BYOD programs (Beimborn and Palitza, 2013). Additionally Hess et al. (2012) extended the scope and evaluated the usability of enterprise app stores for the distribution apps in B2B-markets.

Summarizing, in literature, MDM and MAM are quite often mentioned as a solution to support BYOD, IT-Consumerization and secure mobile enterprise applications (Stieglitz and Brockmann, 2012; Niehaves et al., 2012; Kietzmann et al., 2013; Weiß and Leimeister, 2013; Harris et. al. 2012a). However, currently there exists no research exploring the reasons behind organizational MDM adoption. Thus, our study focusses on closing this research gap and developing and empirically validating a first set of possible factors that influence the adoption decision.

3 Research Model

3.1 Technology Organization Environment Framework

The TOE framework was first developed by Tornatzky and Fleisher (1990). Generally it describes the process by which a firm adopts and implements technological innovations (Tornatzky and Fleisher, 1990) and is based on the diffusion of innovations (DOI) theory by Rogers (1983, 1995). The authors develop characteristics to explain IT innovation adoption based on a meta-analysis of 75 innovation studies. In line with the DOI theory from Rogers (1983) both internal and as well external characteristics of the organization are represented as drivers for IT innovations in the TOE framework (Oliveira and Martins, 2011). Overall the framework helps to better explain information innovation diffusion in enterprises (Hsu et al., 2006).

The TOE states that the adoption process of IT innovations is influenced by three broad areas; (1) the technology context, (2) the organizational context and (3) the environmental context. The technology context includes the external and internal technologies relevant to the firm. This comprises current practices, processes and equipment as well as technologies (Starbuck, 1976; Thompson 1967). The organizational context refers to resources and characteristics of the enterprise. This contains variables like firm size, scope, degree of centralization, degree of formalization, human resources, and linkage between employees (Tornatzky and Fleisher, 1990). The environmental context is described as the surrounding of the firm. This may include the branches, market characteristics, competitors or governmental regulations (Tornatzky and Fleisher, 1990).

The TOE has been used extensively by IS researchers to explain IT adoption in enterprises and provides a useful analytical framework for the development and discussion of specific factors that influence the adoption decision. It has a solid theoretical basis, consistent empirical support and the potential for application across various IS innovations domains (Oliveira and Martins, 2011).

Hence various authors utilized the TOE framework to understand IT-systems adoption for a multitude of different types of systems such as EDI-systems (Kuan and Chau, 2001), e-business/e-commerce (Zhu et al., 2006; Zhu et al., 2003; Ifinedo, 2011; Liu, 2008; Zhu and Kraemer, 2005), websites (Oliveira and Martins, 2008), open systems (Chau and Tam, 1997), supply-chain-management-systems (Lin, 2003), e-procurement solutions (Teo et al., 2009), enterprise resource planning (ERP) (Pan and Jang, 2008), or knowledge management systems (KMS) (Lee et al., 2009). The number and types of analysed variables and as well the adaptation of the TOE framework itself is different in each study. Furthermore, studies have used a variety of different data collection techniques and methods for statistical analysis, e.g. logistic regression (Chau and Tam, 1997) or partial least squares structural equation modelling (PLS-SEM) (Zhu et al., 2006). Table 1 gives a comprehensive overview of TOE studies in the IS domain.

Authors	N (total/ used)	Independent Variables			Dependent Variable(s)
		Technology	Organizational Context	Environmental context	
Chau and Tam (1997)	89	Perceived benefits, perceived barriers, perceived importance of compliance to standards, interoperability, and interconnectivity	Complexity of IT infrastructure, satisfaction with existing systems, formalization on system development	Market uncertainty	Open systems adoption
Ifinedo (2011)	214	*(not considered)*	Management support, organizational IT competence	IS vendor support/pressure, financial resources availability, external pressure, firm size, industry type	Acceptance of internet/e-business technologies

Kuan and Chau (2001)	575	Perceived direct benefits, perceived indirect benefits,	Perceived financial costs, perceived technical competence	Perceived industry pressure, perceived government pressure	EDI adoption
Lin (2013)	283	Perceived benefits, perceived costs	Firm size, top management support, absorptive capacity	Trading partner influence, competitive pressures	Likelihood of e-SCM adoption, extent of e-SCM adoption
Lin and Lin (2008)	163	IS infrastructure, IS expertise	Organizational compatibility, expected benefits of e-business	Competitive pressure, trading partner readiness	e-business adoption
Liu (2008)	156	Support from technology, human capital, potential support from technology	Management level for information, firm size	User satisfaction, e-commerce security	e-commerce adoption
Oliveira and Martins (2008)	3155 small, 637 large firms	Technology readiness, technology integration, security applications	Perceived benefits of electronic correspondence, IT training programmes, access to the IT system of the firm, internet and e-mail norms	Web site competitive pressure	Website adoption
Oliveira and Martins (2009)	2626	Technology readiness, technology integration, security applications	Perceived benefits of electronic correspondence, IT training programmes, access to the IT system of the firm, internet and e-mail norms	Website competitive pressure, e-commerce competitive pressure	Information technology adaption
Pan and Jang (2008)	99	IT infrastructure, technology readiness	Size, perceived barriers	Production and operation improvement, enhancement of products and services, competitive pressure, regulatory policy	ERP adoption
Teo, Lin and Lai (2009)	141	Perceived direct benefits, perceived indirect benefits, perceived costs	Firm size, top management support, information sharing culture	Business partner influence	E-procurement adoption
Teo, Ranganathan, Dhaliwal (2006)	249	Unresolved technical issues, lack of IT expertise and infrastructure, lack of interoperability	Difficulties in organizational change, problems in project management, lack of top management support, lack of e-commerce strategy, difficulties in cost-benefit assessment	Unresolved legal issues, fear and uncertainty	Deployment of B2B e-commerce
Zhu, Kraemer (2005)	624	Technology competence	Size, international scope, financial commitment	Competitive pressure, regulatory support	e-business adoption
Zhu, Kraemer, Xu (2003)	3103	Technological competence	Firm scope, firm size	Consumer readiness, competitive pressures, lack of trading partner resources	Intent to adopt e-business
Zhu, Kraemer, Xu (2006)	1867	Technological readiness, technological interaction	Firm size, global scope, managerial obstacles	Competition intensity, regulatory environment	E-business initiation (technology), e-business adoption (organizational), e-business routinization (environmental)

Table 1.   Overview of Research Based on Tornatzky and Fleisher (1990)

However, no work could be identified analysing the adoption of software for managing mobile work in general or MDM systems in particular. MDM can be understood as an own class of software, prevailing used and managed by employees of the IT department. Nevertheless, the adoption pertains all employees using mobile devices. In our study, we develop and empirically test an initial model for MDM adoption based on the TOE framework described above.

3.2   Environmental Context

Many companies may adopt a technology due to the influence excreted by their business partners (Kuan and Chau, 2001). Particularly for emerging topics, IT managers often force an active information retrieval process and consult business partners, searching for best practice scenarios (Bassellier and Benbasat, 2004). In some cases, decisions are justified by referencing to best practices in other companies. If business partners use or recommend a technology, a firm might feel pressure to adopt the technology itself. This phenomenon has been intensively studied in IS from the perspective of institutionalism (e.g. Butler, 2003; Chatterjee et al., 2002; King et al., 1994). In this context, the concept of mimetic isomorphism refers to the fact that, when facing uncertainty, decision-makers will model their organization on others that they believe to be successful (DiMaggio and Powell, 1983). As MDM is a quite new technology aspiring in the past two years, there is high uncertainty among IT-managers with respect to its adoption, which increases the effect of external recommendations. The adoption of MDM is thus likely to be influenced by the behaviour of business partners. Therefore, we hypothesize:

> *H_1: Recommendations of business partners will have a positive effect on mobile device management adoption.*

Moreover, the adoption of IT-systems is often driven by policies and regulations remitted by the government or other external entities (Kaun and Chau, 2001). In this context, research on the organizational adoption of IT systems has drawn on the concept of coercive isomorphism, referring to pressures from organizations on which a firm is dependent (e.g. headquarters, governmental agencies, etc.) (DiMaggio and Powell, 1983). In addition, external regulations have also frequently been studied as factors in other TOE models (Kuan and Chau, 2001; Pan and Jang, 2008). Particularly in Germany, where the empirical investigation took place, several privacy and data security policies exist for enterprises, e.g. informational self-determination (right of privacy), data privacy act or telecommunications act. Enterprises admitting the usage of privately owned mobile devices (BYOD), must consider even more regulations. For instance they have to ensure that, private data cannot be stored in enterprise systems and are not accessible by the IT staff (Lebek et al., 2013; Duell, 2012). Enterprises have to shape their IT-landscape regarding the existing laws, which sometimes ends in adopting new technologies or leads to novel internal regulations and compliance policies. MDM systems offer a multitude of functions, supporting the IT department to implement and control existing regulations (e.g. government policies, compliance). Due to the facts above, we suggest to build the following hypothesis:

> *H_2: Existing regulations will have a positive effect on mobile device management adoption.*

3.3   Organizational Context

Based on the model of Tornatzky and Fleisher (1990), the organizational context should be considered as one influence factor for IT adoption. In this context, several existing studies on TOE and organizational adoption of IT systems have integrated company size as one important factor. In this context, studies show that larger businesses have more resources to adopt new technologies while smaller businesses are limited in their ability to realize risky investments and need to focus on core business activities, which are directly aiming on increasing the company's profit (Chau and Tam, 1997). More specifically, with respect to mobile IT, it can be argued that the more employees a firm employs the more mobile device are used or can potentially be used in the future. Moreover larger enterprises are more likely to request structured processes, a higher degree of security and control-mechanisms for their IT-management (Chau and Tam, 1997). Thus, it appears reasonable that larger businesses have higher needs and could more easily adopt IT-management systems, simply due to their larger scale of operations (Thong, 1999). Due to this we hypothesize:

> *H_3: The firm size will have a positive effect on mobile device management adoption.*

Very closely related to the overall size of an enterprise is the level of mobile IT usage within the enterprise. A mobile device management system adoption will only generate benefits if smartphones or tablets are utilized for work tasks or, more particularly, if company data is accessed on these devices (Stieglitz and Brockman, 2012; Dery and McCormik, 2012). These types of mobile devices mainly shape the group of mobile devices, which are manageable with current MDM-systems (Humme, 2013; Beimborn and Palitza, 2013; Hemker, 2012). Thus, if the level of mobile IT usage is high, it is likely that enterprises will feel a higher need to implement control mechanisms that govern the mobile access. Based on these arguments the hypothesis H_4 is formed:

> **H_4:** *The level of mobile IT usage will have a positive effect on mobile device management adoption.*

With respect to mobile work environments, current IS literature identifies BYOD and as well IT-consumerization as trends that challenge managers (Harris et al., 2012a, 2012b). While IT consumerization refers to the fact that more and more consumer-grade devices are used for work, BYOD refers to an increasing number of private devices being used in the organizational context (Ortbach et al., 2013). IS literature states that MDM systems may be an appropriate solution solving BYOD caused challenges, like managing the variety of different devices and keeping devices secured and controlled (Harris et al. 2013, Stieglitz and Brockmann, 2012). This would suggest that companies allowing BYOD will be more likely to adopt MDM to account for these challenges. On the other hand, however, enterprises allowing BYOD, are commonly associated with less strict compliance policies and a faithful and loose enterprise culture. Thus, these enterprises may actually feel less pressure to adopt MDM systems (Weiß and Leimeister, 2013b). Therefore, as it remains unclear if BYOD has a positive or negative effect on MDM adoption, we postulate the following hypothesis:

> **H_5:** *The BYOD culture will have an effect on mobile device management adoption.*

Another influencing factor on MDM adoption, such as for other technologies as well, is the degree of innovativeness of the employees (Oliveira and Martin, 2008; Teo et al., 2006; Lin and Lin, 2008). The level of personal innovativeness with respect to IT has had a long tradition in IS research and was first developed by Rogers (1983, 1995). However innovative employees are more likely to try out new technologies both in private and professional usage. As mobile devices are quite new on the market and experience an ongoing improvement, they can be categorized as a new technology. For that reason, it can be assumed that a higher innovativeness will lead to an increased and more intensive mobile device usage within enterprises. This might enhance the pressure for IT executives to adopt MDM systems. Due to this we hypothesize:

> **H_6:** *The innovativeness of employees will have a positive effect on mobile device management adoption.*

3.4 Technology Context

Research on organizational IT adoption has identified managerial support and beliefs towards a particular technology as key factor influencing the adoption decision (Infinedo, 2011; Lin, 2013). Recent studies have shown that management commitment and support tend to increase the adoption of technological innovations in organizations (e.g. Iacovou et al., 1995; Premkumar and Roberts, 1999; Beatty et al., 2001; Chwelos et al., 2001). Similarly, Jeyaraj et al. (2006) found top management support to be one of the best predictors of organizational adoption of IS innovations, because top managers act as change agents in the adoption process of technological innovations (Thong et al., 1996). If the management has a positive attitude towards a particular system and feels confident that it will create benefits for the organization, this will foster its implementation within the organization. For that reason we state the following hypothesis H_7:

> **H_7:** *The prevalent managerial attitude towards MDM will have a positive effect on mobile device management adoption.*

Another variable that has been used several times as independent construct in TOE research on IT adoption is that of perceived benefits (Chau and Tam, 1997; Teo et al., 2009; Lin, 2013). With respect to mobile IT, IS literature suggest security issues to be one of the major challenges management is confronted with (Harris et al. 2012b, Weiß and Leimeister, 2012; Dery and MacCormick, 2012). Looking at it the other way around enhancing the level of mobile security in enterprises is one of the major benefits for enterprises adopting MDM-systems. Thus, if MDM is perceived to lead to higher security of the mobile IT, the managerial assessment of its importance is likely to increase as well. For that reasons we postulate the following hypothesis:

> *H_8: Perceived security benefits will have a positive effect on the managerial attitude towards MDM.*

In opposite to perceived benefits, perceived barriers are also frequently added as independent variable in organizational IT adoption models (Pan and Jang, 2008; Kuan and Chau, 2001; Chau and Tam, 2001). These barriers have a negative impact on the managerial attitude towards a particular system. For instance, Chau and Tam (1997) identified major barriers of system adoption, including the cost of migration, the technical expertise of existing IT staff, and the degree of entrenchment with a proprietary technology (Chau and Tam, 1997). Other researchers have also identified costs to be one of the most important barriers (Wang et al., 2010; Teo et al., 2009). In this context, Teo et al. (2009) differentiate between setup, running and training costs. If these costs are perceived to be high, the managerial attitude towards that particular technology is likely to be more negative. Thus, we hypothesize:

> *H_9: Perceived costs will have a negative effect on the managerial attitude towards MDM.*

The complete research model is shown chapter 5.3 Figure 1. The list of items for each variable as well as the related literature is presented in the appendix of this paper.

4 Methodology

We collected our data using the open source Internet survey tool LimeSurvey v1.92+ (Schmitz et al., 2011). The questionnaire was developed in English and then translated to German. Each question was mandatory, but had an option "no answer" which was later treated as missing value. We distributed the questionnaire using different channels. On the one hand, we sent out emails to chief information officers (CIOs) and IT executives using a mailing list of the chamber of commerce of North Rhine Westphalia. In addition, we also had the link to the survey posted on three German online blogs on mobile device management and mobile enterprise. The survey was accessed 264 times. However, only 121 persons started to fill in the questions and 95 completed the entire questionnaire. For our analysis we finally used these 95 data sets. Our sample included companies from a variety of industries including IT and telecommunication (27%), production (12%), logistics (5%) and tourism (5%). Furthermore, with respect to company size, the sample included small enterprises with less than 50 employees (25%), medium size enterprises with an employee count between 50 and 1,000 (43%) and large enterprises with more than 1,000 employees (26%)

Our dependent variable MDM adoption was measured using a binary measurement following related studies in the context of TOE (e.g. Chau and Tam, 1997; Zhu et al., 2003). The company size was assessed using a categorical variable (see appendix) which was then transformed into a scale to allow for model calculation. All other items were measured using a Likert-7 scale.

We analysed our data using partial least squares structural equation modelling (PLS-SEM) (Ringle et al., 2012). We used the software tool SmartPLS 2.0 (M3) to support the analysis process (Ringle et al., 2005). We ran the PLS algorithm using the centroid weighting scheme in order to prevent overestimation of the effects which is considered an issue with the commonly used factor weighting

scheme (Wilson and Henseler, 2007). Missing values in our data set were treated using the case wise replacement algorithm within SmartPLS.

5 Results

5.1 Measurement Model Assessment

Our outer model comprises reflective constructs only, which need to be analyzed with respect to construct validity and reliability (Ringle et al., 2012). Most of the items show loadings above .7 and, can thus be considered reliable. However, the reverse coded item EITI3 had a loading of .478, which is low even for explorative research (Chin, 1998). Consequently, we dropped the item for further calculations off our model. In addition, MDM3 showed a loading of .687 which is also slightly below the threshold. Following Chin (1998), values above .50 or .60 are acceptable in case of explorative research if AVE and CR are above their individual threshold, which is given in our case. Accordingly, the item was retained for the calculation. Table 2 shows an overview of the calculated item loadings and cross-loadings.

	BYOD Culture (BYOD)	Employees' innovative-ness with IT (EIIT)	Perceived Costs (COST)	Perceived Security Benefits (SEC)	Managerial attitude towards MDM (MA)	Business Partner Influence (BPI)	Regula-tions (REG)	Mobile IT Usage (USE)	Company Size (SIZE)	MDM Adoption (ADOPT)
BYOD1	0.8562	0.2283	-0.0100	-0,0375	-0,2391	-0,0971	-0,1553	-0.0625	-0.3295	-0.2838
BYOD2	0.8649	0.4091	-0.0665	0,0064	-0,1755	-0,0645	-0,0935	0.1145	-0.192	-0.2058
BYOD3	0.9121	0.2067	0.0062	-0.1935	-0.2786	-0.2629	-0.2512	0.1654	-0.4173	-0.4994
EIIT1	0.3732	0.8072	-0.1272	0.3845	0.1908	0.1659	0.2028	0.3824	0.0578	-0.0404
EIIT2	0.2604	0.9371	-0.1934	0.5078	0.2294	0.1783	0.1677	0.5282	-0.0126	0.1155
EIIT4	0.3261	0.9514	-0.1306	0.5512	0.2617	0.1743	0.3331	0.4811	0.0750	0.1295
COST1	-0.0481	-0.1039	0.8364	-02103	-0.4293	-0.2655	-0.3828	-0.0855	-0.2331	-0.2279
COST2	0.1376	-0.1196	0.8263	-0.2031	-0.4726	-0.2643	-0.117	-0.1058	-0.2799	-0.3458
COST3	-0.1753	-0.2046	0.7223	-0.1521	-0.3402	-0.2421	-0.1557	-0.2241	-0.0350	-0.2784
SEC1	-0.0537	0.4771	-0.1321	0.6865	0.3001	0.115	0.3479	0.2289	0.1223	0.0455
SEC2	-0.0274	0.3906	-0.0137	0.7642	0.2467	-0.0679	0.2957	0.2301	0.0641	0.1632
SEC3	-0.1504	0.4610	-0.3018	0.8422	0.5114	0.3666	0.4808	0.3458	0.3802	0.4283
MA1	-0.2466	0.3061	-0.5737	0.4861	0.9449	0.3637	0.4945	0.2460	0.4958	0.5941
MA2	-0.2720	0.1701	-0.3806	0.4369	0.9093	0.3566	0.4853	0.1921	0.5587	0.4831
BPI1	-0.1739	0.2100	-0.2511	0.2359	0.3705	0.9180	0.2770	0.1245	0.4959	0.4243
BPI2	-0.1768	0.1034	-0.3355	0.2034	0.3145	0.8580	0.3224	0.0283	0.3409	0.3276
REG1	-0.3062	0.2441	-0.2666	0.5237	0.5203	0.3765	0.932	0.2495	0.5424	0.4333
REG2	-0.2217	0.2716	-0.2709	0.5019	0.5116	0.3395	0.9451	0.2595	0.6005	0.4368
REG3	-0.1182	0.2470	-0.2246	0.3969	0.4434	0.2135	0.8916	0.2207	0.4373	0.2512
REG4	0.0089	0.1947	-0.1805	0.3267	0.3434	0.1592	0.7525	0.2172	0.4232	0.2054
USE1	0.1636	0.4673	-0.1218	0.3247	0.2668	0.0715	0.2768	0.7935	0.0167	0.0137
USE3	0.0029	0.4076	-0.1412	0.2665	0.1220	0.0774	0.1593	0.8160	-0.0611	0.0144
SIZE1	-0.3896	0.0298	-0.2454	0.2993	0.5634	0.4803	0.5807	-0.0289	1.0000	0.6133
ADOPT1	-0.4248	0.1597	-0.3577	0.3307	0.5868	0.4285	0.4049	0.0174	0.6133	1.0000

Table 2.   Calculated Item Loadings and Cross-Loadings

To assess construct validity we use the internal consistency reliability (ICR, Cronbach's Alpha). Hinton et al. (2005) suggest accepting constructs with an ICR above .5, which is the case for all our constructs except Mobile IT Usage (see table 3). However, as Cronbach's alpha tends to underestimate ICR (Hair et al., 2013), we also calculated the composite reliability (CR) which was above the satisfactory threshold of .7 for all of our constructs (Nunally and Bernstein, 1994). With regard to convergent and discriminant validity, we follow Fornell and Larcker (1981) who argue that the square root of the average variance extracted (diagonal elements in table 3) should be higher than the correlations between the constructs (off-diagonal elements in table 3). As this is given for all of our constructs, they can be considered valid and work as intended.

	ICR	CR	Mean	SD	BYOD	EIIT	COST	SEC	MA	BPI	REG	USE	SIZE	ADOPT
BYOD	0.8673	0.9099	3.18	1.97	0.88									
EIIT	0.9294	0.9279	4.29	1.59	0.29	0.90								
COST	0.7135	0.8385	3.87	1.21	-0.02	-0.17	0.80							
SEC	0.6771	0.8097	5.22	1.28	-0.12	0.58	-0.24	0.77						
MA	0.8392	0.9246	4.96	1.89	-0.28	0.26	-0.53	0.5	0.93					
BPI	0.7374	0.8822	2.76	1.90	-0.2	0.18	-0.32	0.25	0	0.89				
REG	0.9094	0.9339	5.07	1.54	-0.22	0.27	-0.27	0.51	0.53	0.33	0.88			
USE	0.4563	0.7862	4.98	1.32	0.1	0.54	-0.16	0.37	0.24	0.09	0.27	0.80		
SIZE	1.0000	1.0000	3.55	1.21	-0.39	0.03	-0.25	0.3	0.56	0.48	0.58	-0.03	1	
ADOPT	1.0000	1.0000	0.51	0.50	-0.42	0.16	-0.36	0.33	0.59	0.43	0.4	0.02	0.61	1

Table 3.   Validity Figures and Correlation Matrix

5.2 Common Method Bias

All of our survey data is self-reported and hence may be subject to common method bias (CMB) (Liang et al., 2007; Podsakoff and Organ, 1986). In order to test for CMB, we conducted Harman's one-factor test (Cenfetelli et al., 2008; Podsakoff and Organ, 1986) and entered all 25 variables of our study into an explorative factor analysis. The Kaiser criterion (Eigenvalues greater 1) suggested the extraction of 7 factors from our data. Here, the first factor accounted for 26.51% of the variance. Thus, as no single factor occurred, it is unlikely that the data is biased (Cenfetelli et al., 2008; Liang et al., 2007; Podsakoff and Organ, 1986). We also performed the test suggested by Pavlou et al. (2007) and examined the correlation matrix of our constructs (see table 3). The authors suggest, that correlations below .9 indicate the absence of CMB. This is the case for our study.

5.3   Structural Model Assessment

The results show that both company size ($p<.05$) and managerial attitude towards MDM ($p<.01$) have a significant positive effect on MDM adoption. As a result, hypotheses H_3 and H_7 were confirmed. Here the influence of the company size was strongest. In addition, BYOD culture had a significant ($p<.05$) negative effect on MDM adoption, thereby confirming hypothesis H_6. Furthermore, we found that both perceived security benefits and perceived costs had a significant influence on managerial attitude towards MDM within the companies. In consequence, hypotheses H_8 and H_9 could also be confirmed. Conversely, we did not find evidence supporting our hypotheses with respect to environmental influences on MDM adoption. Effects of institutional forces and regulations on our dependent construct were low and insignificant. Thus, hypotheses H_1 and H_2 had to be rejected. Similarly, the level of mobile IT usage and IT experience of employees also showed insignificant

effects on MDM adoption. Consequently, hypotheses H_4 and H_5 had to be rejected as well. Our verified research model is shown in Figure 1.
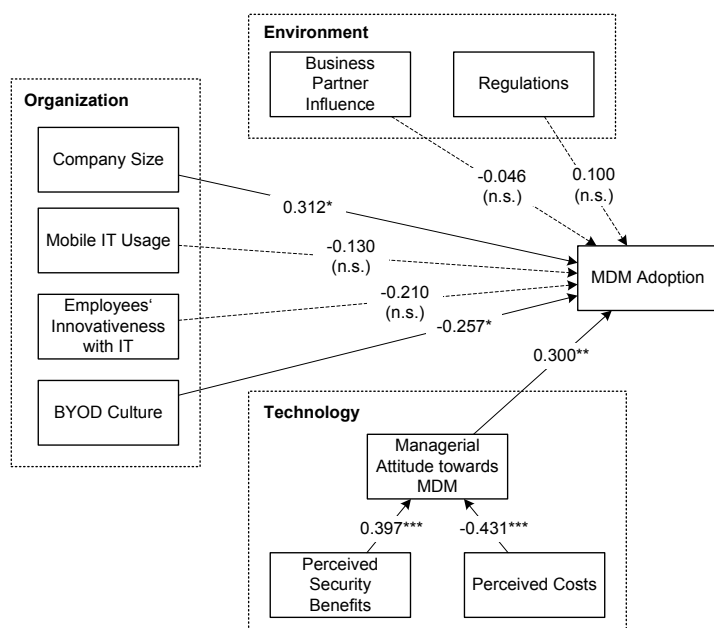

Figure 1.   Structural Model Results

The amount of explained variance of the mediating construct 'managerial beliefs towards MDM' is on a moderate level (R^2=0.4249) (Chin, 1998). Similarly, the coefficient of determination of our final dependent variable MDM adoption can also be considered moderate (R^2=0.5326).

6   Discussion and Conclusion

6.1   Relevance for Mobile IT Management

With respect to organizational factors, we found that company size and BYOD culture both significantly influence MDM adoption. The larger the company, the more likely it is to implement a MDM solution. This is not surprising as large companies usually have a more complex IT infrastructure and mobile access to company systems needs to be centrally managed with respect to different user roles. In smaller companies, the risk of data leakage is usually lower due to fewer devices and a lower number of different employee roles. In addition, the effort associated with implementing and maintaining a MDM system is quite high (Basso and Redman, 2012; Humme, 2013), thus making a setup unprofitable for just a few devices. From this discussion it becomes obvious that the generic measurement of company size based on the number of employees as proposed by related TOE studies (Liu, 2008; Pan and Jang, 2008) may need to be adapted to include the number of mobile devices or the complexity/diversity of mobile IT as mediating constructs.

Regarding the BYOD culture, our study revealed a negative influence on MDM adoption, meaning that companies which grant a larger amount of autonomy to their employees regarding the use of private devices are usually less likely to implement a MDM system. This is an interesting finding because it suggests that the cultural aspect of a BYOD culture with respect to trust in the employees outweighs the need for establishing harder control mechanisms as reaction to the increased number of devices that span both the private and the business environment. As developed in section 3, one could have expected that if allowing BYOD, companies would be more likely to set up control mechanisms that govern the additional devices entering the company. However, allowing BYOD seems to be

strongly associated with the rethinking of traditional control structures. Our results suggest that the trend is associated with a shift towards more trust in the employees, and that the effect of this changing culture outweighs that of the increased need for control.

Surprisingly, we could not confirm that the IT innovativeness of the employees plays a role in this context. We were unable to find a significant relationship between employee innovativeness and MDM adoption. Also, mobile IT usage measured by the percentage of work within an organization that is done by means of smartphones and tablets did not have a significant effect on MDM adoption. Here, it is likely that only the overall number of devices is important and not the extent to which they are used for work.

Furthermore, external influences had no significant impact on the MDM adoption decision in our study. Both, business partner influence and external regulations with respect to the security of company data turned out to be insignificant predictors. Regarding business partner influence, this is likely a result of the fact that MDM systems do not cross organizational boundaries. Partners along the supply chain are not directly affected by the adoption or non-adoption and do not have to adapt any processes. The hypothesized effect of recommendation due to own positive or negative experiences or the fear of losing sensitive data that is stored in collaborative environments could not be measured. Rather surprising is the fact that also external regulations did not have a significant impact on MDM adoption. While many companies reported a high level of privacy and security regulations (mean: 5.07) they have to comply to, they did not perceive MDM to be a useful tool to enforce these regulations. One possible reason for this may be that companies which have to comply to a large set of external regulations completely prohibit mobile access to their company data or limit it to email accounts that can easily be managed without buying, configuring and maintaining a complex MDM system.

As for technology related factors, we found that managerial attitude towards the importance of MDM systems is a major driver for their organizational implementation. While this is not surprising, we also found that these beliefs are strongly influenced by the evaluation of both costs and security benefits. If MDM is perceived to increase data security, this perception will positively influence the mindset of managers with respect to MDM importance. The opposite is true for perceived costs. If the costs associated with the initial setup and the training of the IT staff is perceived to be high by IT executives, management shows a significantly lower assessment of the importance to adopt MDM. In our survey, the majority of organizations regarded the security benefits as well as the costs of MDM as rather high. As managers are generally driven to lower risks by establishing control mechanisms, MDM is likely to be implemented without considering the needs of the employees. Here, the additional amount of control may lead to lower levels of job satisfaction or performance.

6.2 Contribution

Our study offers several contributions to both theory and practice. First, from a theoretical perspective we applied and tested the established TOE framework in the context of MDM adoption. As a result, we provide an initial set of factors that influence the adoption decision and were able to show that especially managerial beliefs towards the usefulness of these systems, company size and BYOD culture are determining factors. Here, in addition to adapting existing measurement constructs and verifying them in the context of MDM adoption, we also developed the construct BYOD culture which may be used in future research in the context of IT consumerization and BYOD to measure the level of autonomy with respect to the use of private technologies in organizations. In our research we investigated that the BYOD culture has a negative impact on MDM adoption, which opens new fields for future research. Moreover, concerning to the diffusion of beliefs, we were able to show that the opinion of IT executives regarding both security benefits and costs are a strong antecedent of the general managerial attitude towards these systems. Thus, when developing and promoting MDM solutions, vendors need to focus on providing a comprehensive feature set with respect to security

management and a transparent cost structure. Due to the high influence of company size on the adoption decision, scalability and transparency of the licensing model may become an important factor influencing the MDM selection.

6.3 Further Research

Our study does not come without limitations that need to be addressed. First, our results are based on a limited sample of 95 companies. However, with respect to the validity of PLS results, IS literature suggests that the number of observations should be at least ten times the maximum number of arrowheads pointing to a latent variable (Barclay et al., 1995). In our case, this requirement is fulfilled. Second, the sample only includes German companies and was drawn using convenience sampling. Since the survey link was posted on MDM blogs in addition to distributing it to random IT executives via mail, the sample cannot be considered representative and, as a result, generalizability of the findings is limited. However, looking at our sample demographics and the variance within our independent variables, there was a considerable amount of diversity. Thus, we believe that our results are still valid for the German market. Third, while we drew on related TOE literature to come up with potential factors influencing MDM adoption and also added factors like BYOD culture to account for the specific nature of MDM systems, we may have missed important factors. For instance, we did not consider the complexity of the (mobile) IT infrastructure with respect to diversity in both hardware and software. Nevertheless, as our model explains over 53% of the variance in our dependent variable, we are confident that our initial set of factors is a promising first step towards the explanation of MDM adoption. Future research may build on this foundation and expand the model with additional technological, organizational or environmental factors.

Moreover, future research could focus on extending the sample to other regions. In addition, future studies could also investigate the effects different factors have on each other. Even though this is uncommon for TOE research, this may provide valuable insights into the relationships among the constructs. For instance, it would be possible to evaluate the effect of external regulations on BYOD culture or that of BYOD culture on managerial beliefs towards MDM. With respect to our findings in the context of BYOD culture, future studies could also focus on exploring the relationship between autonomy with regarding the use of private devices and the need to control these devices more fully. In this context, it will be important to go down on a micro level and evaluate the implications MDM adoption has for the employees.

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Appendix

TOE	Variable	Items	Literature
External Environment	Business Partner Influence (H1)	BPI1: The implementation of MDM has been recommended by large business partners. BPI2: The implementation of MDM has been recommended by a variety of our business partners.	Kuan and Chau 2001, Chau and Hui 2001
	Regulations (H2)	REG1: Within the enterprise, there are many existing standards with regard to the protection of the enterprise data. REG2: The access to enterprise data is strongly regulated. REG3: There are many existing standards with regard to the protection of the privacy of the employees. REG4: My enterprise has to comply with many legal regulations concerning the protection of personal privacy.	self-created
Organizational Context	Enterprise Size (H3)	SIZE: How many employees does your company have?	Thong (1999), DeLone (1981)
	Mobile IT-Usage (H4)	USE1: To what degree are smartphones deployed in your enterprise? USE2: To what degree are tablets deployed in your enterprise?	Chau and Tam (1997)
	Employees' Innovativeness with IT (H5)	EIIT1: If our employees hear about a new information technology, they will look for ways to experiment with it. EIIT2: Our employees often immediately try out new information technologies (compared to the employees of different enterprises). EIIT3: Our employees like to experiment with new IT.	Argawal and Prasad (1998)
	BYOD Culture (H6)	BYOD1: Our enterprise allows employees to use their private mobile devices for business operations. BYOD2: Our enterprise enables employees to access the enterprise infrastructure via their private mobile devices. BYOD3: Our enterprise promotes the use of private mobile devices within the business context.	self-created
Technology Context	Managerial attitude towards MDM (H7)	MA1: The management of my enterprise thinks that the implementation of MDM is important. MA2: Our IT department thinks that the implementation of MDM is important.	self-created
	Perceived Security Benefits (H8)	The implementation of a mobile device management system… SEC1: …increases the security of data transmission (encryption of data). SEC2: …increases the security of enterprise data through remote control. SEC3: …facilitates better compliance.	based on Chau and Tam (1997) Teo et al. (2009), Lin (2013)
	Perceived Costs (H9)	The implementation of a mobile device management system… COST1: …is adjunct to high acquisition costs. COST2: …is adjunct to a high installation expenditure. COST3: …is adjunct to high training cost for the responsible IT department.	Chau and Tam (1997)
IT-Innovation Adoption (Dependent Variable)	MDM-Adoption	ADOPT: My enterprise currently uses an MDM system.	Chau and Tam (1997)