Augmented Reality Smart Glasses and Knowledge Management: A Conceptual Framework for Enterprise Social Networks

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Abstract

Augmented Reality Smart Glasses are an emerging new wearable technology that integrates virtual information in a user's view-field. In this article, the authors discuss the opportunities of smart glasses in the context of Enterprise Social Networks (ESN). A proposed conceptual model is developed that demonstrates the underlying mechanisms that drive smart glasses ESN adoption on a firm level. Furthermore, on the individual employee level, the authors propose the antecedents to active and passive use. The theoretical contribution is a comprehensive hierarchical model that extends prior technology acceptance and ESN research. On the managerial front, the article provides guidance to managers who aim at achieving competitive advantages by improving knowledge management through the use of new wearable Augmented Reality technologies.

Keywords

Web 2.0 · Enterprise social networks · Augmented reality · Virtual reality · Adoption · Technology acceptance model · Expected cost-benefit ratio

5.1 The Complementarity of Enterprise Social Networks and Smart Glasses

Competitive advantage in a globalized economy is the result of many integrated processes working smoothly and efficient knowledge management is one of them. The acquisition and dissemination of information and the subsequent generation and use of knowledge was greatly affected by the "Web 2.0"-trend. This online-trend is fundamentally about the democratization of content creation capability, as it enabled users of social networks to create their own content, coining the term "user-generated content" (Hennig-Thurau et al. 2010). Starting on the consumer side, the "Web 2.0"-trend brought about platforms like YouTube, Facebook and Twitter, turning users into prosumers—producers and consumers of content.

Online social networks and other Web 2.0-technologies were recognized to offer tremendous potential in terms of internal collaboration and knowledge management. This idea led to the widespread installation and use of so-called Enterprise Social Networks (ESNs), which are, broadly speaking, internal Web 2.0 tools. Typically, these internal networks are accessed through the most common end devices in business settings: browsers on laptop and desktop computers, or other handhelds like iPads or smartphones.

However, technological progress is pushing the boundaries of IT availability even further. Wearables, in particular Augmented Reality Smart Glasses, are the most recent advances in information and communication technology. Augmented Reality Smart Glasses, for example, are worn like regular glasses and include virtual information in a user's view field. The advantages of this new smart glasses technology are tremendous. For instance, because of their augmented reality technology, these devices are able to understand everything in their line of sight and connect it to knowledge retrieved online. Additional information can then be displayed in a user's view field and integrated on the right place, offering situationally relevant information in the most comprehensible manner reducing risk of misunderstandings and fostering use of databases through maximum availability. Furthermore, users can operate them handsfree as they are controlled via voice or maybe even gaze. Studies have shown that these devices possess great relevance for both consumer and business contexts (Rauschnabel et al. 2015a; Krulikowski et al. 2015). However, fundamental research on the extent to how they can assist companies and in what way they can contribute to the functionality of ESNs is scarce.

We suggest that the new technology of Augmented Reality Smart Glasses and the established and accepted IT-infrastructure of ESNs form natural complements, as they fulfill different roles in knowledge management. We think that by their nature, these technologies are designed to serve each other because ESNs may serve as the source and storage of information that the technology feeds upon and that their users gather. In this article, we develop this notion further by elaborating on use cases and suggesting a framework of antecedents to successful adoption derived from a literature review of established models. We close by discussing how managers should progress in order to achieve successful implementation. Thus, we provide answers to the following research questions:

1. How can Augmented Reality Smart Glasses increase process efficiency?
2. How can Augmented Reality Smart Glasses increase knowledge sharing efficiency in ESN?
3. What drives the acceptance and use of Augmented Reality Smart Glasses on a corporate and on an individual level?

5.2 Definition of Augmented Reality Smart Glasses

Augmented Reality Smart Glasses are defined as wearable Augmented Reality (AR) devices that are worn like regular glasses[1]. Augmented Reality Smart Glasses merge the real world with virtual information that is overlaid/integrated in a user's view field. Prominent examples are Google Glass, Elbit/Everysight Raptor, Microsoft HoloLens, or Epson Moverio. Using various sensors, including GPS, microphones, and cameras, smart glasses can analyze and 'understand' a user's physical environment. Mobile internet technologies can then provide additional virtual information and integrate them into a user's perception of the real world. For example, Google Glass provides a prism located in the front of a

[1] In this article, we use the term 'smart glasses' as a synonym for Augmented Reality Smart Glasses. However, it is important to note that some manufacturers (e.g., K2) offer products that are branded as 'smart glasses' that are basically sunglasses with integrated mp3-payers (i.e., headsets). The definition of smart glasses in the current research excludes these and similar devices without Augmented Reality components.

user's eye. Depending on the model, smart glasses can be controlled by one or several of the following ways: speech, touchpad on the device, motion of the user's head, or virtual displays (e.g., holographic buttons) that a user can touch via external devices (such as a smartphone).

However, Augmented Reality Smart Glasses are not the only type of wearables, especially not the only type of wearable glasses. Unlike Augmented Reality Smart Glasses, where digital content is overlaid onto the real world, Virtual Reality Glasses (VR Glasses, e.g., Ocolus Rift) are completely closed off from the physical world, and instead present only a virtual world. Likewise, the Apple Watch and Samsung Gear are examples of smart watches, another type of wearable devices. Smart watches, and other wearables such as smart textiles or smart wristbands, do not cover any AR or VR technologies.

5.2.1 Prior Research on Augmented Reality Smart Glasses

Both manufacturers and scholars highlight the potentials of smart glasses for value creation. So far, three streams of research have emerged, with all of them investigating smart glasses from their own perspective. We term these streams' perspectives as 'technical', 'application', and 'behavioral'.

The first research stream includes studies with a **technical focus**. These studies have discussed various ways of how to realize AR technologies in glasses (e.g., Azuma et al. 2001) and how to visualize content best. Those articles usually have an IT or engineering background and thus provide the technological groundwork that is necessary to realize and apply the technology in different domains.

Studies with an **application focus** have assessed how smart glasses can be used in various contexts. For example, a recent study by Muensterer et al. (2014) revealed the potential of using smart glasses for collaborations among doctors. Likewise, other researchers have discovered the potential of smart glasses to guide visitors in museums (Tomiuc 2014; Wojciechowski et al. 2004) or as a means of safely producing video footage on industrial maintenance procedures (Quint and Loch 2015; Yang and Choi 2015). In a recent Harvard Business case study, Eisenmann et al. (2014) discuss the opportunities of smart glasses for value creation and summarize the managerial importance of this generation of wearable devices. Wall et al. (2014) present an application that can be used to manage diets in diabetes management, thus supporting diabetics. For agricultural firms, smart glasses can be used to monitor the plant health by assessing chlorophyll concentration (Cortazar et al. 2015), and doctors (as well as other professionals) can use the built-in camera to document their environment in their view field (Albrecht et al. 2014; Armstrong et al. 2014). With regards to the purpose of this article, studies addressing issues in this research stream provide a basis to theorize potential outcomes of smart glasses as a collaboration tool.

Finally, those studies with a **behavioral perspective** addressed issues with regards to user acceptance and are grounded in the marketing and/or information systems literature. For example, studies have shown that consumers with high levels of adoption intention are usually innovative people, who see several function benefits in smart glasses and perceive certain levels of social pressure and social conformity in smart glasses, and expect them to be used quite easily (Rauschnabel et al. 2015a, b). Likewise, Hong (2013) discusses potential adoption challenges, such as negative reactions of other people who insult Google Glass users as 'glassholes', a bad design, violations of privacy concerns, technical limitations, or uncomfortable use. Finally, in a study conducted by Morpace Inc and the University of Michigan-Dearborn, 1000 US consumers were surveyed about their perceptions and feelings towards smart glasses (Krulikowski et al. 2015). The study shows that around one third of the respondents think that wearing smart glasses makes people look 'strange' (25.3 %), and that using smart glasses threatens other people's privacy (29.7 %). Surprisingly, one 15.9 % valued the benefits of smart glasses to make one's life more efficient and only 12.4 % thought that using smart glasses is easy. These studies were exclusively conducted among consumers rather than employees. However, to the best of the authors' knowledge, no prior research has investigated behavioral aspects of users in a work-related context. This gap is somehow surprising, as smart glasses are one of the most intensely and promisingly discussed technologies in professional settings (Murley 2015). In the following section, we will briefly discuss the potentials of smart glasses for companies.

5.2.2 Value Potentials and Use Cases

The discussed differences of smart glasses compared to other existing technology offer various potentials for existing and new businesses to create value (Rauschnabel et al. 2015b). Figure 5.1 classifies the opportunities smart glasses offer to businesses in three groups: New Business Models, Research & Development, and Process Efficiency.

As any smart device, smart glasses are also based on applications (apps). Offering new applications can offer new potentials for businesses to monetize them, for example by

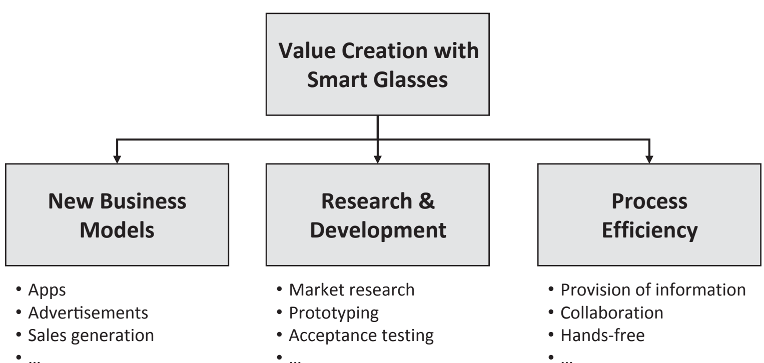

Fig. 5.1 Value creation with smart glasses.(Rauschnabel et al. 2015b)

charging money for the apps, by integrating advertisements, or by stimulating additional purchases. Companies, such as 'RE'FLEKT', focus on the development on AR applications for smart glasses and other mobile devices.

In **Research & Development**, smart glasses can offer new ways of **market research**, such as identifying brand logos, qualitative observations, and possibly even eye-tracking in the future. SenseGlass is an example of an application that can track and 'understand' human emotions (Hernandez and Picard 2014). This and other similar apps offer enormous potentials for products, advertising, and usability tests. Moreover, as intensely promoted by Microsoft's HoloLens smart glasses, three dimensional holographic representations of new products can be presented. These holograms can be modified by product developers and also be shown to potential consumers in market research studies.

Finally, smart glasses can offer tremendous potential for manufacturers to **increase efficiency** in many ways, which is also the focus of this article. For example, what has been termed as 'pick-by-vision' represents the idea of providing warehouse workers with smart glasses who then get an optimized navigated route through warehouses. Handsfree use of smart glasses allows higher speeds of information processing. For instance, a worker can be guided to a particular product, pick it up and the integrated camera automatically scans the QR-code/barcode and processes this information in the ERP system. Microsoft promotes the application of HoloLens in improving collaborations between employees. Likewise, examinations from medical settings (Armstrong et al. 2014; Hashimoto et al. 2015) show a similar potential of Google Glass in allowing collaborations between doctors in surgeries. This application of sharing knowledge can be transferred to other professional contexts and may culminate in an ESN that is both filled and consulted by employees using smart glasses.

Whereas the extant literature provides a good understanding how smart glasses can contribute to an organization's process efficiency, the knowledge about the underlying mechanisms remains limited. Furthermore, whereas prior research on internal collaborations has shown that ESNs are an effective tool for collaborations, and smart glasses are too, the role of smart glasses in ESNs has not been investigated yet. After providing a brief overview of extant research streams that have emerged on smart glasses technology so far, we propose a conceptual framework that explains the adoption drivers and barriers as well as expected outcomes of smart glasses as a tool for knowledge sharing.

5.3 Smart Glasses for Knowledge Sharing

In the previous section, we provided several examples of how smart glasses can increase process efficiency, because relevant information can automatically be displayed in one's field of view in real-time. That is, information that is not relevant at a time can be filtered out, and by doing so, reduce the risk of information overload. Furthermore, the automatic augmentation of a user's reality reduces cognitive efforts in searching the right information. Finally, information in one's view-field can be more accurate than existing alternatives, such as a tablet or a paper-manual. For example, the AR technology could guide a mechanic plugging in the right cables in the right slots in real-time. This means that this information is automatically updated—for example, once a worker plugged in a cable, the next step of the process is automatically integrated in his or her view field. This is likely to reduce time, distraction, and information overload.

But where does this relevant information come from? There is not just one answer on that question, as this is dependent on the apps that are used in a particular context. However, one future potential can arise from ESNs. Following Turban et al. (2011), ESNs—sometimes called enterprise networks or corporate networks—are online social networks. Those are very similar to their public equivalents, created by a specific company that regulates its terms of use, that is, who may use the network and what for. Their basic functionalities are often similar to traditional 'Intranets'. However, a core difference to Intranets is that ESN users can serve as content-prosumers—that is producing and consuming content. Typical applications involve information dissemination and sharing, collaboration, knowledge management and others (Turban et al. 2011). Northrop-Grumman, for instance, uses an ESN to connect more than 120,000 employees who organize themselves in "communities of practice" that focus on specific topics, sharing knowledge, solving problems and constantly improving the firm's knowledge base (Terdiman 2008). It is such institutions that we suggest to profit from the introduction of smart glasses.

Broadly speaking, ESNs provide users access to relevant information—for example, documentation of processes, operating instructions, best practices, FAQs, error analyses, contact information, and others. Two core challenges in extant ESNs are (1) consistent access to the Internet, and (2) the existence and accessibility of relevant information. Only when consumers have access to the internet while they need the relevant information, can ESNs provide this information to users. Mobile devices and Internet technologies (such as 4G/LTE or Wi-Fi) could mostly solve these challenges. However, in many cases, users need relevant information 'at hand' while working.

We propose that smart glasses as a new device technology in ESNs can overcome, or at least reduce, many of these issues and limitations of 'traditional' ESNs. These include, but are not limited to:

- In some situations, having access to handhelds is risky, too distracting or time-consuming, or even impossible, for instance in surgery (e.g. Armstrong et al. 2014). In such time-crucial situations, there is no time to search for existing information. Then AR technologies that automatically 'understand' the issue can identify the required information automatically and present it bit by bit in one's view-field.
- In time-crucial situations where people have to solve yet unknown problems, they might also not be aware of how and where to find these information in ESNs—for example, how a problem can be described in terms of particular search-terms. Smart glasses can use all the available information (e.g. a worker's physical location, visible information, previous requests etc.) to narrow the potential problems down. This enables users to find relevant information faster and easier.

- Information is also particularly useful to a user if it is context specific and provided in a way that is understood by a user. One of the core advantages of ESNs (and employee-generated content) is the access to information provided by people 'like them' (e.g., using familiar expressions, company specific terminologies etc.) that has a very specific focus (e.g., a specific machine, rather than just a common manual). Likewise, many ESNs include communication technologies, such as chats. Smart glasses could include video chats and 'integrate' a colleague in one's view-field. Consider, for instance, the example where a worker has yet unknown problems with a forklift. A service technician can then be integrated into the worker's view-field and provide him/her with the necessary information to solve the issue. Once solved, any idiosyncrasies of the particular disturbance case can be uploaded in form of a video protocol to the ESN, already catering for future circumstances.

In sum, the opportunities of smart glasses in the context of ESNs are immense. But at the same time, many of the challenges of existing ESNs, and context specific ones, arise: There has been a huge challenge in many companies to motivate people to use ESNs (Li 2015). While we discussed that smart glasses make it easier to access relevant information from ESNs, it might also increase the challenge for users to upload own content on the network. For example, while textual content in traditional ESNs is relatively 'impersonal', recording and posting a commented video documentation calls for more courage and spontaneity. Furthermore, implementing and combining smart glasses in a company and in an ESN is associated with several other issues on a firm-level, such as the costs. In the following section, we propose a framework that theorizes the underlying mechanisms that drive the adoption of smart glasses in an ESN context on a firm-level, and the use on an employee-level.

5.4 A Conceptual Model

5.4.1 Groundwork

We propose a hierarchical two-step model, as shown in Fig. 5.2: First, on a firm level, the decision of whether smart glasses in an ESN context should be integrated needs to be modelled. This part of the model is grounded in the literature of firm-level technology adoption (see Chap. 4.1.1) and describes factors that are proposed to drive this investment decision (see Chap. 4.4). The bottom part of the model explains mechanisms that are proposed to influence whether, and how, employees use existing ESN smart glasses technologies (see Chap. 4.5). These propositions are based on the individual level technology acceptance literature (see Chap. 4.2.1).

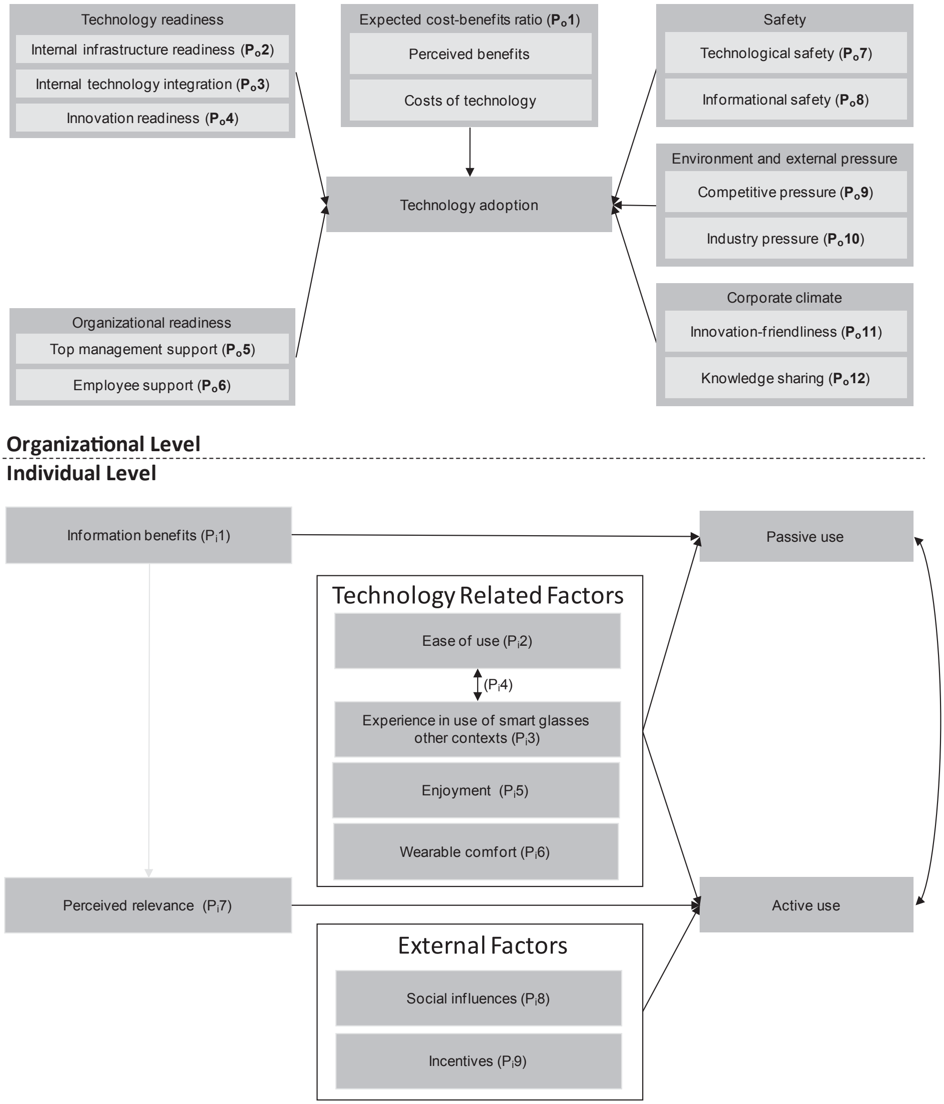

Fig. 5.2 Hierarchical model of smart glasses adoption

5.4.1.1 Prior Technology Adoption Research (Firm Level)

Several theories have been developed that explain the usage of information technology at the firm level which have been developed over time, with the model by Oliveira and Martins (2010) (here: the OM-model) being one the most recent ones. The overall objective is to understand why and when firms adopt particular technologies. This carries special importance, as adoption at the individual level is impossible without previous adoption at the firm level. Theories applied with regard to information system adoption include, for instance, the theory regarding the diffusion of innovations (Rogers 1995), the Technology-Organization-Environment framework (Tornatzky and Fleischer 1990), and the model developed by Iacovou et al. (1995), all three of which have been tested empirically extensively (for an extensive review see Oliveira and Martins 2011).

The Diffusion of Innovations Theory widely relies on firm-endogenous factors as antecedents to adoption (Rogers 1995). According to this theory, underlying the adoption is a complex social interaction process within a social system of which the firm is the focal unit and that takes place over time and between different firms with varying properties. It is assumed that each population can be divided into groups of different size and different innovation adoption proneness. Next to system member characteristics, structural properties of the social system play a vital role in this model (Rogers 1995).

With regard to structural properties, Tornatzky and Fleischer (1990) borrow on the model by Rogers for their TOE framework, that sees the organization as one of three mutually interdependent antecedents for the dependent variable of "technological innovation decision making". This is enriched with perspectives on availability and characteristics of the new technology and properties of the external task environment. This last element is comprised of industry characteristics as well as the market structure, a technology support infrastructure and governmental regulation (Tornatzky and Fleischer 1990). This model's contribution thereby lies in the extension of Roger's model with a contextual component that considers the environment that the adopting unit is embedded within.

The model by Iacovou, Benbasat and Dexter (1995) focuses on the adoption of enterprise data interchange adoption and integration. In contrast to the two models before, it defines the factors of perceived benefits of the innovation, the organizational readiness in terms of financial and IT resources, and external pressure consistent of competitive pressure and trading partner power as antecedents to the outcome. Apparently, this model excludes the notion of a social adoption process and replaces it with a highly rationalized one, which in our view covers important aspects of the adoption process while leaving out others.

The OM-model (2010), in turn, purposefully combines elements from the TOE framework and the model by Iacovou, Benbasat and Dexter (1995), as this approach acknowledges the internal rationalization process that takes place prior to adoption, as well as environmental and internal organizational complexity. Oliveira and Martins (2010) developed their model building on the previously introduced ones in the context of explaining e-business adoption across industries. They integrated an external component, which they named "environment and external pressure", an internal, ratio-directed component named "perceived benefits" consistent of benefits and obstacles, and a factor named "technological and organizational readiness", comprising technology readiness, technology integration and firm size (Oliveira and Martins 2010). We acknowledge the consideration of various perspectives this model is injected with and build on this foundation to develop our own model for the adoption of smart glasses at a firm level. We see this to be necessary, as the focal subjects of adoption differ in certain aspects that call for explanation through different antecedents that we explore in a later section.

5.4.1.2 Prior Technology Acceptance Research (Personal Level)

The acceptance of newly developed technology on a personal level has been subject to research since the advent of the personal computer, achieving its breakthrough in 1989 with a highly cited article on the determinants that drive the adoption of technological systems, the classical "Technology Acceptance Model" (TAM) by Fred Davis (1989).

It represents one of the most widely accepted extensions of the theory of reasoned action (TRA) (Ajzen and Fishbein 1980; Bagozzi et al. 1992). The initial TAM suggests that the perceived usefulness and perceived ease of use of any new technology influence potential users' attitudes towards the acceptance of the technology, which ultimately influences the intention to adopt it (Davis 1989; Bagozzi et al. 1992). Also, TAM hypothesizes that the perceived usefulness also directly drives a user's level of adoption intention. Furthermore, TAM hypothesizes that when consumers perceive a technology as easier to use, they also tend to perceive it as being more useful. Finally, the intention to use a product is hypothesized to predict the actual use of a system. As TAM is rather robust and flexible, it has been adopted into several new contexts and experienced several extensions (a review can be found with Turner et al. 2010 and King and He 2006).

The original TAM is a rather easy to comprehend model—in a nutshell, it implies that how a technology is perceived in terms of its ease of use and its perceived usefulness drives its adoption. Whereas this simplicity represents a common criticism of TAM (Bagozzi 2007), TAM is also associated with high levels of robustness (King and He 2006). Thus, various scholars have refined the original TAM and related theories (e.g., Venkatesh and Davis 2000; Venkatesh et al. 2007; Venkatesh and Bala 2008), or adopted it to specific contexts (e.g., Giannopoulos 2004; Lee and Lehto 2013; Osswald et al. 2012). With regards to Augmented Reality Smart Glasses, Rauschnabel and Ro (2016) used a TAM approach in their consumer research and added specific factors such as privacy factors in the model.

5.4.2 General Characteristics of the Proposed Model

Whereas most traditional TAM literature focuses on the personal level of antecedents and a user's personal environment, in corporate settings, external factors play an important role in personal use of technology. Therefore, similarly to Homburg et al. (2010), we propose a hierarchical model. Moreover, we argue a hierarchical two-step model: First, a corporate decision needs to be made to adopt smart glasses in the corporate environment. We argue that technology- and corporate-specific determinants are important in driving this decision. Once smart glasses are introduced, factors on an individual employee level become important. Here, the established TAM variables and smart glasses specific factors play an important role. Additionally, in the context of ESN, we distinguish between the active and passive use of ESN via smart glasses.

5.4.3 Active and Passive Use as Target Variables

Prior research on ESN has applied various conceptualizations of the use of variables. For example, Kügler and Smolnik (2014) identified a nuanced dimensional structure of ESN use: Consumptive use, contributive use, hedonic use, and social use. Richter et al. (2013) used behavioral activities to measure ESN use—Search, Edit, Rate, Label, Clarify, Notify, and Share. Because of the novelty of the application focus in this research, we use a more general approach, inspired by Pagani et al. (2011): the distinction between the active and passive use, conceptualized as continuums ranging from very low to very high levels or active or passive use, respectively.

Passive use includes consuming content that the company, colleagues, or other users have published in the ESN. This includes, but is not limited to pictures, comments, videos, texts, documentations, and links. Active users also post own content on ESN, which also includes editing or rating content posted by others. Content, in this context, covers all relevant information, such as tips of how to fix a problem, comments and clarification in manuals, or interpretations of error messages. However, provision of content is one way of actively using ESNs. Another one may be its use to get in touch with like-minded colleagues or ones who own information needed, but that are hard to reach otherwise. As visualized by the double-headed arrow, active and passive uses are not independent from each other. That is, for example, people who post a lot of information (i.e., high levels of active use) will also spend more time online in reading other peoples' content in order to identify the need for newer or better information (i.e., also high levels of passive use).

5.4.4 Organizational Level Model

For the adoption of smart glasses at the organizational level, we propose different drivers to be relevant than for individuals, as this level of adoption differs in various ways. For instance, decision processes at a corporate level call for rationalization of investments, a constraint that the individual is free to adapt, yet is not forced to. Likewise, organizational decisions are often influenced by several individuals, departments, and organizations (such as works councils). The explanation of adoption at corporate level is inspired by the O&M-model of e-business adoption that we have outlined in detail in chapter 5.4.1.1.

5.4.4.1 Expected Cost-Benefit Ratio

Investments in new technologies are usually based on a consideration of the expected benefits and costs for the implementation and maintenance of a new technology (Brynjolfsson and Hitt 2000; Premkumar and Roberts 1999; Richter et al. 2013; Tornatzky and Klein 1982). We introduce the term of expected cost-benefit ratio as an overall concept that covers the ratio of all (expected) associated current and future benefits as well as monetary and non-monetary costs of smart glasses for an organization.

Similar to other IT contexts, **perceived benefits** of smart glasses can be subdivided into two categories depending on whether they increase firm performance directly or indirectly through secondary effects (Pfeiffer 1992). Direct benefits of smart glasses include operational savings that come about through improved internal process efficiency or because they could substitute more expensive alternative technologies. Indirect benefits refer to the effects on other business processes and business relationships (Iacovou et al. 1995).

Costs of technology adoption typically stem from external consulting services for planning, hardware and software technology purchase, training of personnel, or communication efforts. Next to these foreseeable costs of implementation, non-monetary costs can arise from drawbacks that the technology brings along. For instance, if vital information leaks through or is shared with unauthorized personnel, this can cause a deterioration of the overall competitive position. Showing of employees' personal information to unauthorized personnel can undermine trust and slow down processes that call for a solid foundation thereof (Hong 2013). These examples illustrate that the adoption of smart glasses comes with benefits, costs, and risks to be accounted for.

Data security issues are a major concern, as smart glasses call for a clear access policy. With regard to the ESN, questions arise through the simultaneous usage by both co-workers and exteriors of the firm. Thereby, it has to be assured that no critical information—neither with regard to persons nor to sensitive business information—will be viewed by the wrong user. This is one example of how data security manifests itself as a complex problem and not surprisingly, a recent survey among managers revealed that managers' fear of low security of data is a core barrier in the adoption of smart glasses in companies (Ballard 2015).

Further criticism that often arise in various public discussion and media is that users might get distracted, exposed to electro smog, or be affected by high operating temperatures of the smart glasses devices—other forms of potential 'costs' that need to be taken into account. However, no prior research has revealed the existence of these negative effects on the user's health so far, which could be explained by the novelty of the technology (Rauschnabel et al. 2015b). However, these potential fears are likely to be claimed by workforce interest, and thus could serve as a barrier to adoption.

P_o1: A positive cost-benefit-ratio positively influences firm level smart glasses adoption.

5.4.4.2 Technology Readiness

Technology Readiness is defined as the simultaneous presence of internal infrastructure readiness, internal technology integration (Zhu et al. 2006) and the innovation readiness of the innovative technology itself, here smart glasses. **Internal infrastructure readiness** can be any internal auxiliary information technology system that possesses the possibility of providing information to smart glasses, either by provision of data or through connectivity (such as 4G/LTE or Wi-Fi). Given the example that warehouse workers shall be equipped with a "pick-per-view"-application, the gap between the information stored in the ERP program, (e.g. "place of storage is in warehouse 2, aisle 4, shelf 17, second board from the top") and the routing information to get there will have to be closed first. This means that the ERP system will have to be complemented with a so-called Geographic Information System (GIS), which enables smart glasses to connect objects and coordinates derived from a GIS into visual routing information within a company. Note that the area-wide provision of connectivity is part of the organizational technology infrastructure. **Internal technology integration** refers to the linkages and migration possibilities of information across system borders of systems in place that use the internet. Given the advantage of smart glasses to be able to integrate information from various sources through the internet, the total absence thereof may represent a serious barrier to the implementation of smart glasses. Insufficient integration may also have an effect on costs to be expected for implementation. Third, the **innovation readiness** is defined as the degree to that the technology in focus, i.e. smart glasses, is able to holistically fulfill potential users' various needs as conveyed through the purchasing department. We expect the purchasing department to bundle the needs that are related to how good the technology is able to support professional processes as well as have an eye out for the users' physical integrity. In case of smart glasses, typical constraints that impede the technology's usefulness regarding professional processes would be, for instance, short battery life or limited quality of graphical representations and camera images (Moshtaghi et al. 2015). A specific assurance of the absence of these potential negative consequences could foster the innovation readiness.

P_o2: Internal infrastructure readiness is positively related to firm level smart glasses adoption.

P_o3: Internal technology integration is positively related to firm level smart glasses adoption.

P_o4: Innovation readiness is positively related to firm level smart glasses adoption.

5.4.4.3 Organizational Readiness

The organizational readiness is defined as the staff's readiness to embrace the technological innovation. We divide the staff into the top management team and the subordinate employees. Support by top management has been shown to influence innovation adoption positively several times, for various reasons. Commonly mentioned reasons include motivational factors for the rest of the staff as well as the capacity to set up a favorable resource allocation for innovation adoption (Kotter 1995; Li 2015). Other employees are also very important, as the work council by rule of governance also plays a vital role in any technology adoption. It is noteworthy that all employees' readiness is of concern, as peers share their opinions and norms amongst each other. Thereby non-users still can affect the users of smart glasses. For instance, if non-users perceive a loss of privacy when others are wearing smart glasses, they might react negatively towards users. Thus, we suggest support from subordinate hierarchical ranks to be a critical factor as well. Early integration of leading work force personnel into the implementation project team may help reduce resistances against new technology adoption, as they may lose the perception of being driven, once made shareholder of the change process (Kotter 1995).

P_o5: Top management readiness is positively related to firm level smart glasses adoption.

P_o6: Workforce readiness positively related to firm level smart glasses adoption.

5.4.4.4 Safety

From both an ethical as well as a business-political viewpoint, any innovation needs to fulfill the safety criterion before being allowed into the corporation. Smart glasses need to be safe in a twofold way: primarily, it needs to be assured that the device is **technologically safe** regarding any injury potential (e.g., broken bits of glass). This may also be interpreted as a sign of innovation readiness as described above. With the development of smart glasses at the current point in time, potential issues yet unsolved include potential eye damage once glasses get shattered, electro smog, and others, as discussed above. With regard to **informational safety**, smart glasses cause the same concerns as social networks in general do. These concerns mainly focus on users losing their autonomy with regard to information concerning them and system administrators exploiting participants (Dwyer et al. 2007). These concerns become amplified by the smart glasses specific features, such as cameras. They may be eliminated by having clear policies and guidelines on how to behave when wearing smart glasses and by introducing clear access permissions to any device.

Both of these issues are not just relevant form an ethical viewpoint, but also are on top of the work council's agenda, as discussed above. In case there is a perception that employee data remains unsafe in any ESN accessible through smart glasses, this will add to efforts against their adoption. However, this notion of low security in many aspects stretches to other groups in the enterprise as well, with the work council being just one, yet rather powerful group. Rather than focusing on the opposing group, we propose that low levels of perceived security (i.e., data, privacy, health) lead to barriers in the adoption on an overall organizational level that is not restricted to the group of the work council alone.

P_o7: Technological Safety positively influences the firm level smart glasses adoption.

P_o8: Informational Safety positively influences the firm level smart glasses adoption.

5.4.4.5 Environment and External Pressure

We include the environment and external pressure into our model as external pressure forces companies to adapt specific technologies, even against organizational inertia. Previous research has identified several of those external factors, such as competitive pressure, industry pressure, and other factors that do not apply in this adoption context (Chwelos et al. 2001; Gatignon and Robertson 1989; Premkumar and Roberts 1999). However, competitive pressure can be interpreted as the ability of smart glasses to maintain or increase competitiveness in the industry. Similarly, industry pressure can be interpreted as the efforts of associations to introduce new standards and encourage technology adoption amongst industry members. These two factors may well play a role in the context of smart glasses, as the technology already shows impact on several industries and redefines some processes' regarded-as-normal performance (Chwelos et al. 2001). With regard to the use of ESNs, it is undisputed that firms of the twenty-first century are in need of effective knowledge sharing systems to achieve competitive advantage (Fulk and Yuan 2013). As these systems have found widespread proliferation, ESNs by themselves have lost their property of being able to constitute such an advantage. The effective introduction of smart glasses into ESNs may, at least temporarily, reinject the system with such a constituting element, providing a firm with the competitive advantage. However, the prerequisites and complexity of the introduction of smart glasses may deter many firms which implies that the advantage from their adoption is a sustainable one.

P_o9: Competitive pressure is positively related to firm level smart glasses adoption.
P_o10: Industry pressure is positively related to firm level smart glasses adoption.

5.4.4.6 Corporate Climate

Being the last hypothesized influencer of the corporate adoption of smart glasses, we suggest the corporation's climate, namely its innovativeness and its knowledge, to be an important antecedent. Following Bock et al. (2005), the term "climate" refers to specific, timely-determined contextual situations with regard to behavior, thoughts and feelings of an organizations' members. These are more prone to shift in the short term than the corporate culture, which consists of beliefs, norms, values shared by members of an organization and that is more stable (Needle 2004). Both, an innovation-friendly climate as well as a climate that emphasizes knowledge-sharing, are relevant to the adoption of smart glasses, especially with regard to their use in ESNs. This is because both impinge upon decision makers to acknowledge the value of committing to risky investments in order to move the organization forward and the potential that is inherent to knowledge sharing (Bock et al. 2005; Kügler et al. 2013). Thus:

P_o11: An innovation-friendly corporate climate positively affects firm level smart glasses adoption.
P_o12: A corporate climate of knowledge-sharing positively affects firm level smart glasses adoption.

5.4.5 Personal Level Model

5.4.5.1 Information Benefits, Ease of Use, and Experience

First, Technology-Acceptance researchers have widely replicated the influence of perceived usefulness (PU) on the adoption intention of new technologies. If users perceive a technology as being useful, they have a more favorable attitude towards using it, whereas PU describes the degree to which a user expects that a technology helps him or her doing his tasks more efficient (Davis 1989; Bagozzi et al. 1992; Venkatesh and Davis 2000; Venkatesh et al. 2007; Venkatesh and Bala 2008).

With regards to smart glasses in a professional setting, we use the term information benefits, defined as the expected value a user receives by getting relevant information in one's view-field. Thus, in situations where the correct content is displayed in a correct way in a user's view field, users are proposed to perceive higher levels of information benefits, which then lead to higher levels of passive use (P_I 1). According to prior TAM-research, this information benefits increases in situations where getting these information is associated with low levels of cognitive effort—that is, with high levels of ease of use (P_I 2). In line with prior TAM research, we also propose that ease of use should be both directly related to the active and passive use of ESN. Furthermore, the more often a user has used smart glasses in any context, the easier he or she perceives the usage of smart glasses to be (P_I 3). This is because a higher familiarity of a technology goes in line with higher levels of self-efficacy. In the context of smart glasses, self-efficacy reflects a user's judgement of the extent to which he or she is capable to operate smart glasses (c.f., Bandura 1977; Venkatesh 2000). Likewise, consumers who perceive smart glasses as being easily to use are more likely to use it more often in various contexts. Thus, similar to smart glasses studies from the consumer context (e.g., Rauschnabel et al. 2015b; Rauschnabel and Ro 2016; Krulikowski et al. 2015), we propose:

P_I 1: Information benefits are positively related to passive use of smart glasses in ESN.

P_I 2: Ease of use is positively related to active and passive use of smart glasses in ESN.

P_I 3: Experience in use is positively related to active and passive use of smart glasses in ESN.

P_I 4: Experience in use is positively correlated with ease of use.

5.4.5.2 Enjoyment

Enjoyment reflects an accepted antecedent of revised technology acceptance models. In the professional context of smart glasses, it describes the extent to which an employee perceives the activity of using smart glasses to be personally enjoyable in its own right aside from the instrumental value (e.g., information benefits) (Davis et al. 1992; Yi and Hwang 2003). Thus, the model proposes that employees who perceive that contributing to smart glasses ESNs is 'fun' are more intrinsically motivated to use the network are more motivated to contribute more actively.

P_I 5: Enjoyment is positively related to active use of smart glasses in ESN.

5.4.5.3 Wearable Comfort

It is important to note that smart glasses, as any wearable devices, also include a fashion component (Kim and Shin 2015; Rauschnabel et al. 2015b). Thus, factors that are known from clothing should also be relevant to the use of smart glasses and in work-related contexts. We use the term wearable comfort to describe the physical comfort (i.e., that wearing them is not associated with physical pressure or even pain) and emotional comfort (i.e., a user does not feel ashamed when wearing them because they make him or her look strange). However, smart glasses next to aesthetic requirements also need to fulfill functional ones, as they are tools worn for work purposes. Drawing on research from commercial tool use context, items that focus on how design elements and tool characteristics match ergonomic principles and allow for a fatigue-proof working experience in the past have been successfully grouped by the general term "design and comfort" (Hein et al. 2015).

P_I 6: Wearable comfort is related to active and passive use of smart glasses in ESN.

5.4.5.4 Perceived Relevance

Empirical findings as well as theory suggest that people who value user-generated content (e.g., find this content useful) and thus use it more, are also more likely to contribute to websites by adding own content (Daugherty et al. 2008; Di Gangi and Wasko 2010). Similar findings have been identified in the literature on open source knowledge platforms, where interestingly the hope to change things is a motivation for participation, but also people's will to foster the visibility of their own potential to improve their own career perspectives or simply the value of being a helpful person (Nov 2007). However, these findings emerged in non-AR-contexts. Our model proposes that employees are more likely to be motivated to contribute to ESNs via smart glasses if they perceive that their input provides value for other users. For example, if they assume that their colleagues use their information in situations of higher urgency, they may predict their peers to perceive a higher value of the provided information, thus being more helpful. Superiors may notice especially helpful contributions and acknowledge their value to the firm, resulting in improved career potentials. These findings imply a connection between perceived relevance and smart glasses adoption.

P_I 7: Perceived relevance of the information provided in ENSs are positively related to active use of smart glasses in ESN.

5.4.5.5 Social Influences

Social influences are especially important in situations where people use a technology visibly around other people. This is where the concept of social norms comes into play, a construct that describes to what extent it is 'common' to use smart glasses (descriptive norms, expected social conformity) or to what extent other people expect a user to use them (injunctive norms). Prior research on media (e.g., Knoll and Schramm 2015) and technology acceptance (e.g., Venkatesh et al. 2003; Venkatesh and Bala 2008; Venkatesh and Davis 2000), ESNs in general and smart glasses (Rauschnabel et al. 2015a; Rauschnabel and Ro 2016) have widely replicated these findings. Likewise, prior research shows that the perception of the value of the technology by the (top) management is a relevant determinant of technology adoption (DeLone 1988; Karahanna et al. 1999). Likewise, Paroutis and Al Saleh (2009, p. 59) conclude that "top management can send strong messages to the organization as to how important sharing knowledge is and people will be more inclined to perform a certain behaviour if they feel that important referent individuals endorse this behaviour and are likely to approve and even applaud it." Thus, in line with prior TAM research (Venkatesh et al. 2003; Venkatesh and Bala 2008; Venkatesh and Davis 2000; Rauschnabel and Ro 2016), we propose social influences to be antecedents. As the passive use is less visible to other people as the proactive use (e.g. the author of content can be identified by names, voice, pictures etc.), these social influences tend to be particularly important for the passive use.

P_I 8: Social Influences are positively related to active use of smart glasses in ESN.

5.4.5.6 Incentives

Potential motives to publish information in ESNs via smart glasses might include intrinsic motivations like perceived relevance (P_i7). Further intrinsic motives that were reported in the literature consist of the will to gain social capital in terms of reputation and the will to set a norm that does not allow social loafing amongst colleagues (Fulk and Yuan 2013). However, managers can also try to motivate peoples' participation more extrinsically. For example, workers might get financial benefits or other visible benefits for the quality and quantity of the content they posted (Farzan et al. 2008).

P_I 9: Incentives are positively related to active use of smart glasses in ESN.

5.4.5.7 The Role of User and Organizational Characteristics

Technology Acceptance literature has shown that personal variables that describe a user—such as his/her personality, demographics, or innovativeness—strongly influence adoption behavior. There have been complex interplays, ranging from direct to moderating effects (Venkatesh et al. 2003; Rauschnabel and Ro 2016). It is very likely that these variables will also play an important role in our proposed model. In other words, it is likely that several personal user characteristics drive the usage intention, and/or influence the strengths of the other proposed effects on the individual level. However, for reasons of clarity, those factors were explicitly not included in the individual model. The same might be true for organizational characteristics. Both, the average level of the individual level constructs as well as the effects proposed in P_i1-P_i9, might be influenced by the magnitude of organizational level variables. These possible extensions of the model will be further discussed later.

5.5 Discussion

Prior research and practical experiences in industry generally agree that ESNs are a useful technology. However, traditional ESN applications and technologies are associated with some limitations—for example, how consumers can access information. After discussing these limitations, we suggest that smart glasses, a generation of wearable augmented reality devices, could overcome these limitations. To better understand this approach, we developed a conceptual model based on prior research and established models in technology acceptance, ESN, and smart glasses.

5.5.1 Theoretical Contribution

First, this model contributes to the large stream of technology acceptance research by proposing a dynamic and hierarchical model that takes into account both firm- and individual level factors. By doing so, it extends prior TAM models (Davis 1989; Bagozzi et al. 1992; Venkatesh and Davis 2000; Venkatesh et al. 2007; Venkatesh and Bala 2008; King and He 2006; Rauschnabel and Ro 2016).

Second, several studies have discussed the potentials of smart glasses for professional uses from an applied perspective (e.g. Armstrong et al. 2014; Moshtaghi et al. 2015; Muensterer et al. 2014; Tomiuc 2014). Other studies have applied technology acceptance (Rauschnabel and Ro 2016) and other established theories (Rauschnabel et al. 2015a) on smart glasses, academic research for an internal application remained scarce. Now, with this article, the literature is extended by a conceptual model that includes both an individual and an organizational level to better understand the adoption and use of smart glasses in a professional context.

Third, by discussing smart glasses from a new perspective, antecedents that have not yet been studied intensely in prior TAM and smart glasses research were discussed (e.g. wearable comfort). For example, wearable comfort.

5.5.2 Managerial Contribution

For each phase of the implementation process, our framework allows deduction of managerial implications and steps to take. Beginning with the pre-assessment phase at the organizational level, identification of value potentials suited best for respective purposes is called for. As this is a strategic decision, it should lie at the top management level. This stage is about the determination of which focus to put on the implementation: Should it lie on the creation of new revenue streams by offer extension, improvement of R&D and market research capabilities or on the strengthening of other internal process efficiency? Once this question is answered, responsibilities shift to a lower level and concrete plans and roadmaps should be developed. This calls for the installation of a project team at middle-management level, which directly reports back to the top any finding of interest. This team needs to consist of tech-savvy managers with a strong social network within the organization and enough resources to not get stuck in daily business. Tasks this team will face need to be checks for compatibility with processes, culture, people and technology in place, as well as a profitability check for the overall project. The aspect of IT compatibility plays a big role in the expected cost-benefit-ratio, as the implementation of smart glasses calls for an open IT architecture in place. This is mandatory, because the setup of such can be a costly factor in implementation, deteriorating the expected cost-benefit-ratio. With regard to organizational readiness, the work force's representatives should be integrated into the decision making process at this stage already. Privacy issues should be addressed and solutions should be developed. Overall, the security of the system with regard to information and physical integrity needs to be communicated. The adoption can be facilitated if the corporation develops an awareness of its openness to innovation and the value of shared knowledge. Support from industry associations and the knowledge of competitors' efforts who try to go new ways on their own may further motivate to adopt smart glasses at the organizational level. For the individual level, benchmarks need to be put in place in order to able to track performance improvements. Furthermore, a communicational roll-out campaign needs to be established in order to set the required social norms we introduced as part of framework throughout the entire staff. It is mandatory to include all employees, as not only the operators of smart glasses are affected. Contents for the campaign to be included are (1) ease of use and enjoyment, (2) incentives for use as well as (3) productivity gains to be expected.

In the implementation phase, focus shifts to the factors concerning the individual level. We suggest for the organizational level to support individual level adoption through the provision of trainings to personnel in order to familiarize staff with the technology and overcome other hurdles to technology use. Furthermore, lead users need to be identified and innovators within the population need to be equipped with internal media reach. These lead users may serve as experts to help fellow colleagues overcome initial difficulties and clear out open questions. In order to help individuals develop the motivation to adopt, a system of incentives can be put in place. As the familiarity of the system pays into the accounts of both active and passive use, smart glasses application does not need to stay limited to its use in the ESN-context. Possibly, other uses can be found that familiarize staff with them while at the same time developing positive associations. For instance, smart glasses can introduce aspects of gamification into the workplace, to some extent causing enjoyment and thereby supporting the individual adoption, once employees realize the full potential for both work and entertainment purposes.

In the post implementation phase, we suggest permanent updates of interfaces and data security programs for maintenance. In order to keep security high in the ESN, constant work on permissions needs to be administered. Access rights to files and information need to be permanently updated, as the employee base constantly changes. This is apparent as occupations may change through job rotation, people going on parental leave or changing departments. To further consolidate use, the incentive for smart glasses application can be institutionalized with regard to norms and values in the corporation. For example, prizes can be awarded to the most active users on the ESNs, the best contribution, postings with the highest number of consultations, thereby signaling appreciation and actively shaping the internal climate.

5.5.3 Limitations and Future Research

Smart glasses are a relatively new technology, and the idea of using them as a device for ESNs has just been developed in this research. For these reasons, we could not validate the proposed model empirically which, as a consequence, provides an opportunity for further research. Therefore, researchers should start with the development of appropriate measurement scales. There is a long tradition in technology acceptance research that scales need to be adjusted to the context (e.g., Homburg et al. 2010). Especially with smart glasses as a substantially new technology, qualitative research might be necessary to identify appropriate items.

Moreover, to keep the model clear, we did not include detailed propositions of specific constructs, such as personality or innovativeness, constructs that have been shown to be important in predicting smart glasses usage (Rauschnabel et al. 2015a; Rauschnabel and Ro 2016). Future research should address this. Furthermore, in hierarchical models, cross-level effects could be existent. For example, one could questions whether the degree of technology readiness influences the average perception of information benefits. Likewise, organizational factors could have an influence on the strength of the proposed relationship on an individual level (cross-level interactions). This should be specified and validated in future research.

More avenues of future research emerge by the applications of smart glasses in other fields. As we discussed in Fig. 5.1, three ways of how smart glasses can create value exist. This study contributes to 'process efficiency', and more research in this area is necessary to better understand these potentials. With regards to the high expectations companies have on smart glasses applications in warehouses and operations management, this research is imperatively necessary. Besides this, future research could assess the conditions in which smart glasses can be used for R&D, and how successful applications and business models are characterized.

5.6 Conclusion

With this article we have shown how smart glasses possess relevance in terms of increasing process efficiency through an improved knowledge management. The use cases we have presented only cover few applications; potential uses of the technology seem to be more diverse and some not even discovered yet. However, any use can only be the consequence of previous adoption. Organizational and individual adoption comes with various obstacles that need to be overcome. In this article, we have shown difficulties, what to consider and made suggestions on how these obstacles can be overcome by management. Our framework may serve as foundation to further research on this important topic or as an illustration of how framework development in an entirely new technological context may be carried out.

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