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Research article

Effect of user resistance on the organizational adoption of extended reality technologies: A mixed methods study

Henri Jalo [*,1], Henri Pirkkalainen [2]

Tampere University, PO Box 541, 33101 Tampere, Finland

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ABSTRACT

Although organizations are increasingly adopting extended reality (XR) technologies to transform their operations, their adoption has been slower than initially expected. Scholars and practitioners have pointed to user resistance as a potential hindrance to their adoption. This mixed-methods study examines how managerial perceptions of expected employee resistance and organizational value are related to organizational adoption intention. An organizational-level resistance-value adoption model was developed and tested using the structural equation modeling approach with cross-sectional data from 206 European industrial decision makers. The results show that trialability, internal support capabilities, and extant user skills are negatively associated with expected employee resistance. Moreover, mimetic pressures strongly influence value perceptions, whereas expected employee resistance is negatively related to organizational value perceptions and adoption intentions. Perceived value had the strongest positive relationship with adoption intention. A qualitative study consisting of 58 interviews further revealed 12 key conditions affecting the relationships between resistance, value, and adoption intention. As a theoretical contribution, we proposed and validated an integrated resistance-value adoption model that extends our understanding of factors affecting organizational XR adoption. As a practical contribution, practitioners can use the study's results to help them focus on relevant factors for mitigating user resistance and promoting XR adoption.

1. Introduction

Extended reality (XR) technologies, which include augmented reality (AR) and virtual reality (VR), are increasingly being adopted by organizations to bolster their competitiveness and respond to the new demands of digital and remote work (Chuah, 2019; Dwivedi et al., 2022, 2023; Masood & Egger, 2020). Recent examples include Accenture acquiring 60,000 VR headsets to train their workers (Fink, 2021) and Mercedes-Benz USA training 1200 of their dealership technicians to use AR headsets in remote maintenance (Castellanos, 2021). Although XR technologies have remarkable potential in facilitating collaboration and displaying information to organizational users in novel and effective ways (Hennig-Thurau et al., 2023), such as reviewing designs remotely in VR rather than using physical mockups (Wolfartsberger, 2019), their adoption has been slower than many industry analysts and researchers initially expected (Chuah, 2019; Grand View Research, 2021). As XR technologies can be used to radically transform organizational activities throughout the organizational value chain (Dwivedi et al., 2022; Porter & Heppelmann, 2017; Torro et al., 2021), these kinds of considerable changes can also create broader resistance to adopting such new ways of working (Chuah, 2019; Kim & Kankanhalli, 2009). While initial research on XR adoption has identified users' resistance to change as an important barrier (Badamasi et al., 2022; Davila Delgado et al., 2020), there is still a dearth of research on the role of user resistance in organizational adoption dynamics. This article aims to address this research gap.

Although the importance of user resistance in organizational technology adoption failures has been widely noted by scholars (e.g., Ali et al., 2016; Kim & Kankanhalli, 2009; Laumer & Eckhardt, 2012), much of this research has focused on individual users (e.g., Kim & Kankanhalli, 2009; Laumer et al., 2016). In contrast, the role of user resistance in organizational adoption dynamics has received less attention. However, as central drivers of organizational change (Vagnani & Volpe, 2017), managers' beliefs about the potential level of employee resistance to adopting a technology are likely to have a significant influence on

* Corresponding author.
E-mail addresses: henri.jalo@tuni.fi (H. Jalo), henri.pirkkalainen@tuni.fi (H. Pirkkalainen).
[1] ORCID 0000-0003-1438-700X
[2] ORCID 0000-0002-5389-7363

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whether it is implemented in the organization (Jeyaraj et al., 2006; Markus, 1983). Thus, decision makers' value assessments of novel technologies are likely to be highly dependent on their expectations of their employees' responses to their implementation. Due to the wide application potential of XR (Chuah, 2019; Porter & Heppelmann, 2017), it is important to holistically consider how expected resistance is related to adoption at the aggregate organizational level. Therefore, understanding the interplay between expected employee resistance and perceived organizational value can yield important insights into critical aspects that affect organizational adoption of XR. *The main objective of this study is to examine how decision makers' perceptions of the expected level of employee resistance to XR and the value of XR are related to organizational adoption and what conditions amplify or mitigate these relationships.*

A mixed-methods approach was used in the study. In the first quantitative study, we drew on the organizational-level value-risk adoption model presented by Gao et al. (2012) and conceptualized expected employee resistance as a specific adoption risk. The proposed research model incorporating the effects of these two proximate antecedents of organizational adoption intention, namely, expected employee resistance to XR (as perceived by managers) and the perceived organizational value of XR, was then extended with the technology–organization–environment (TOE) framework (DePietro et al., 1990) to ascertain which distal antecedents enhance value perceptions or diminish the expected level of resistance from employees. The research model was tested using the structural equation modeling (SEM) approach with cross-sectional survey data from 206 managers and decision makers from European industrial companies. In addition, a second qualitative study was conducted based on 58 interviews with European industrial managers to provide a richer understanding of the dynamics and conditions affecting the relationships between the three key variables of the study (i.e., resistance, value, and adoption intention).

The present study contributes to information systems (IS) research by theorizing and validating a research model that integrates user resistance and value perspectives, examines their relationships with organizational XR adoption intention, and specifies under which conditions these relationships are amplified or mitigated. This contribution enhances our understanding of the dynamics that affect the adoption of emerging technologies, such as XR, wherein the role of resistance is likely to be more prominent than for established technologies. Furthermore, this study provides additional contextualization to earlier qualitative findings at the organizational level of analysis (e.g., Lapointe & Rivard, 2005) by quantitatively validating the significance of the user resistance construct and its role in organizational adoption considerations. The study also has practical implications, as the validated model can help managers focus their efforts on factors that are critical in mitigating resistance and promoting XR adoption.

The rest of the paper consists of the following sections. Section 2 examines the theoretical background of XR and user resistance in organizations. Section 3 describes the mixed-methods study design. Section 4 presents the research model and hypotheses for Study 1, along with the survey design, data collection methods, and the results of the quantitative data analysis. Section 5 describes the qualitative data collection methods, analysis techniques, and findings for Study 2. Finally, in Section 6, the results and findings are discussed along with the theoretical and practical contributions of the study. We conclude with the study's limitations and suggestions for future research.

2. Theoretical background

2.1. AR and VR in organizational use

AR can be defined as a technology that *combines or superimposes digital elements into the user's view of the real world with handheld devices, such as smartphones and tablets, or with head-mounted displays (HMDs)* (Azuma, 1997; Masood & Egger, 2019). Although AR HMDs offer superior interactions, freedom of movement, and better tracking of the environment, smartphones and tablets are still the most common way for users to utilize AR, as they are far more accessible than AR HMDs (Billinghurst, 2021). In contrast, VR can be defined as a technology that *transports the user into an immersive and interactive 3D environment with a spatial presence* (Bryson et al., 1995; Shu et al., 2019). In particular, recent developments in HMD-based immersive VR have been remarkable (Hennig-Thurau et al., 2023; Torro et al., 2021), which was also the focus of our study.

AR and VR are often examined together, as they enable users to interact with digital information in more immersive and interactive ways (e.g., Davila Delgado et al., 2020; Noghabaei et al., 2020; Steffen et al., 2019). Recent research also suggests that awareness, perceived adoption limitations, and the actual use of AR and VR are at similar levels in organizations (Jalo et al., 2022). Many industry leaders also believe that AR and VR are converging, with both technologies being increasingly integrated into single hardware offerings (Robertson, 2021; Stein, 2021). Researchers and practitioners have recently referred to AR and VR using the umbrella term XR (Chuah, 2019; Dwivedi et al., 2021, 2022). This study also examines these two technologies simultaneously under the XR label.

In addition to their use in the consumer context, XR technologies have found many uses in industry (Lounakoski et al., 2022). Industrial XR use cases include, for instance, remote immersive design reviews (Devanesan, 2020), training and onboarding of workers (Fink, 2021), marketing and sales (Lounakoski et al., 2022), and remote operational support (Porter & Heppelmann, 2017). Examples from industry indicate that XR offers substantial performance and quality improvements. For instance, Kia Motors went from spending several days on face-to-face physical design reviews to completing remote XR reviews of designs within a few hours (Devanesan, 2020). Productivity improvements of 25 % or more are often reported in various manufacturing activities (Porter & Heppelmann, 2017). As organizational value appropriation examples begin to mount, organizations are increasingly considering the adoption of XR technologies to enhance the efficiency of their operations and to maintain their competitiveness (Dwivedi et al., 2022, 2023; Jalo et al., 2022).

Previous research has identified several critical factors for organizational XR adoption. A review of the extant literature can be found in Appendix A (Table A1). Some of the key identified factors include the maturity of XR hardware (Davila Delgado et al., 2020; Masood & Egger, 2019), IS compatibility with XR (Jalo et al., 2020, 2022; Masood & Egger, 2019), aversion to change (Badamasi et al., 2022), user acceptance and inertia (Berg & Vance, 2017; Masood & Egger, 2019, 2020), XR expertise availability (Badamasi et al., 2022; Chandra & Kumar, 2018; Davila Delgado et al., 2020), the existence of a champion (Berg & Vance, 2017), top management support (Chandra & Kumar, 2018; Jalo et al., 2022), and pressure from competitors using XR (Jalo et al., 2022). Specific technology-related reasons for user resistance to XR range from XR's higher levels of immersion compared with other IT (Mütterlein & Hess, 2017) to possible virtual motion sickness (Chang et al., 2020), and the novel interaction methods associated with XR (Wolfartsberger, 2019).

Although extant studies have made valuable contributions to our understanding of factors affecting XR adoption, more detailed conceptualization is still needed on how different XR adoption factors are related to each other at the organizational level. Lastly, XR adoption research has primarily examined factors that can help organizations adopt XR, while rarely focusing on factors contributing toward non-adoption, such as user resistance.

2.2. How do managerial expectations of user resistance affect XR adoption in organizations?

User resistance can be defined as *users' overt or covert behaviors aimed at preventing the implementation of a new system or avoiding its use after* *implementation, which can prevent the implementers of the system from achieving their goals* (Markus, 1983). Our study examines, in particular, how managerial expectations relating to the potential level of user resistance affect organizational adoption considerations. As XR technologies can be used to significantly transform employees' job roles and work characteristics (Torro et al., 2021), many employees are likely to resist such radical changes either passively or actively (Heidenreich & Handrich, 2015), thereby hindering the adoption of XR in organizations. Thus, even though many pioneering companies have already achieved significant benefits from adopting XR solutions (Porter & Heppelmann, 2017; Torro et al., 2021) and many organizations are increasingly considering their adoption (Dwivedi et al., 2022), employee resistance is likely to have an important contributing role in limiting XR adoption (Chuah, 2019).

A wide variety of factors contributing to individual user resistance have been identified in the extant literature. These include, for example, perceived threats posed by the technology to an employee's position within the organization (Bhattacherjee & Hikmet, 2007; Kim & Kankanhalli, 2009), high switching costs and individuals' tendency to favor the status quo (Kim & Kankanhalli, 2009; Talke & Heidenreich, 2014), continued use of previous systems due to inertia (Polites & Karahanna, 2012), technology anxiety (Tsai et al., 2019), colleagues' attitudes toward the new technology (Kim & Kankanhalli, 2009), and cynicism toward the implementers' goals (Selander & Henfridsson, 2012). Personality characteristics have also been found to affect people's disposition to resist change and how negatively they respond to the introduction of mandatory IS (Laumer et al., 2016).

The negative effect of user resistance on usage intention has been empirically confirmed at the individual level, and it has been found to be significant, albeit less so than the perceived usefulness of a technology (Bhattacherjee & Hikmet, 2007). The findings from individual resistance research also have implications for organizations as a whole. As individual employees contribute to the overall level of resistance to adopting a technology, managers will need to estimate how their employees will respond to the introduction of new technologies beforehand (Fink, 1998), for example, by identifying what threats employees perceive in the new technology and by assessing their relative importance (Bhattacherjee & Hikmet, 2007).

Since user resistance is a multi-faceted phenomenon, managers may find it difficult to create an accurate picture about what form it will take with specific technologies in their organization. User resistance is also unlikely to be expressed in a uniform fashion by employees; while some employees may be supportive, others may passively or actively resist adoption (Heidenreich & Handrich, 2015; Talke & Heidenreich, 2014). Furthermore, users may still use the technology, even if they resist it, or support its adoption while not actively using it themselves (van Offenbeek et al., 2013). Nevertheless, managers need to address resistance, because left unaddressed, resistance can later escalate into group behaviors (Lapointe & Rivard, 2005; Rivard & Lapointe, 2012), making it much harder to mitigate (Selander & Henfridsson, 2012). However, managers may also feel unable to address user resistance, or they may lack the inclination to tackle it proactively (Rivard & Lapointe, 2012). Managers' perceptions of the overall level of user resistance to XR can thus be affected by many factors, and this will likely have a significant effect on adoption, as the uncertainty related to user resistance can create risks in the adoption of XR.

2.3. Integrating expected resistance and organizational value perspectives

Users' resistance to change has long been noted as one of the critical reasons for failed organizational IS implementations (Jiang et al., 2000; Keen, 1981; Markus, 1983). Thus, this can be seen as a critical risk factor that managers need to take into account when considering the implementation of new technologies. One of the most established theoretical models explaining individual user resistance in the organizational context was proposed by Kim and Kankanhalli (2009). In their model, individual factors (self-efficacy), external factors (organizational support and colleague opinion), and perceived value and its antecedents, namely switching benefits and switching costs, were theorized to explain a user's resistance behavior toward adopting new enterprise systems. Their results highlighted the key role of perceived value and organizational support in reducing user resistance and how switching costs significantly increased user resistance. However, this model cannot be directly employed to examine the adoption of technologies at the organizational level because managers tend to evaluate the value of a technology in an overall organizational context (Dwivedi et al., 2015; Selander & Henfridsson, 2012).

Given that the individual user resistance model may not apply in explaining the organizational adoption of XR as such, the conceptualization of user resistance as an organizational risk (see Section 2.2) can be used as an anchor to extend the theoretical understanding of resistance in the organizational-level adoption context. Relatedly, Gao et al. (2012) proposed and validated a model in which perceived value and perceived risk jointly influence organizations' intention to adopt expensive, discontinuous technologies. As XR arguably falls into this category, the findings of their study are highly relevant to our research context. Similar to Kim and Kankanhalli's (2009) model, Gao et al.'s (2012) model also included internal and external factors (internal adoption readiness and external market pressure, respectively) as antecedents of perceived value and perceived risk. Although their results showed a positive association with value and adoption intention, as well as a negative association with risk and adoption intention, the relationship between perceived risk and perceived value was not found to be significant.

Based on user resistance literature (Kim & Kankanhalli, 2009; Markus, 1983; Rivard & Lapointe, 2012) and the preceding discussion, we define expected employee resistance to XR as *the manager's overall assessment of the potential level of opposition from the organization's employees to adopting XR*, and propose it as a specific risk in organizational technology adoption. Relatedly, we define perceived organizational value of XR as *the manager's overall assessment of XR's benefits and its implementation costs for the organization* (Gao et al., 2012; Kim & Kankanhalli, 2009). Since implementers need to consider potential resistance from employees when adopting a new system (Klaus et al., 2010; Rivard & Lapointe, 2012), this is also likely to influence their value perceptions. Thus, these two perspectives—expected employee resistance and perceived organizational value—are likely to have a primary influence on whether an organization intends to adopt XR. However, to the best of our knowledge, how potential or expected employee resistance to a technology affects decision makers' beliefs about organizational adoption intentions or value perceptions has not been examined through quantitative research.

The alignment of the two theoretical models has further potential for two reasons. First, researchers have noted the importance of integrating the concept of resistance into broader technology adoption models, as purely resistance-focused models can explain an organization's adoption intentions only so far (Bhattacherjee & Hikmet, 2007). Earlier organizational adoption research has also highlighted the primary importance of perceived value when organizations consider adopting a technology (Bhattacherjee & Hikmet, 2007; Gao et al., 2012). However, managerial attitudes and perceptions about user resistance are likely to decrease an organization's intention to adopt technologies that are likely to face resistance from employees, despite its perceived organizational value, as the non-use of a technology resulting from user resistance can negate any potential value the technology has for an organization (Ali et al., 2016; Markus, 1983). Nevertheless, the significance or magnitude of this effect is still unknown. Thus, it is crucial to understand the effect that resistance may have on organizational value perceptions and adoption intentions. Second, the shared antecedents for user resistance and perceived organizational value suggest a common link between these two perspectives. Uncovering the more nuanced mechanisms of how these distal antecedents affect the two aforementioned primary influences can provide a clearer picture of organizational XR adoption dynamics. Furthermore, as these managerial perceptions do not develop in a vacuum, it is essential to consider how various contextual factors, such as the technology itself, the organization adopting the technology, and the organization's external environment, affect these perceptions (DePietro et al., 1990).

2.4. Categorizing the distal antecedents of perceived organizational value and expected employee resistance using the TOE framework

Scholars have stressed the importance of accounting for a wide range of factors that may influence the organizational adoption of technologies (DePietro et al., 1990; Jeyaraj et al., 2006). While the models proposed by Gao et al. (2012) and Kim and Kankanhalli (2009) showed how various organizational and environmental factors affect perceived value and resistance, they did not include the technological context in their models. However, given the unique characteristics of XR compared to other IT solutions (Mütterlein & Hess, 2017; Porter & Heppelmann, 2017), and the significant emphasis on technological factors in the extant organizational XR adoption literature (see Appendix A), the inclusion of the technological context seems warranted. Therefore, we extended the organizational and environmental antecedent categories shared between the aforementioned models by adding the technological context in our research model. Consequently, the technology–organization–environment (TOE) framework, which has found consistent empirical support in the organizational adoption literature (e.g., Chandra & Kumar, 2018; Masood & Egger, 2019; Ramdani et al., 2009, 2013), was used in categorizing the distal antecedents for expected employee resistance and perceived organizational value (DePietro et al., 1990). To provide a comprehensive analysis of the relevant factors affecting XR adoption, we included six key TOE-based factors as direct antecedents of expected employee resistance and perceived organizational value based on our review of organizational XR adoption literature (see Appendix A).

First, we included XR compatibility with organizational IS in our research model, as compatibility has been observed to facilitate the seamless integration of XR into current business processes (Jalo et al., 2020, 2022; Masood & Egger, 2019). Second, trialability has been found to be important in XR adoption because it enables organizations to evaluate the benefits and challenges related to XR beforehand (Jalo et al., 2020, 2022). Moreover, extant research has encouraged scholars to validate its importance in the context of radical innovations (Gao et al., 2012; Yoon & George, 2013). These antecedents can be characterized as *technological factors* affecting XR resistance and adoption (DePietro et al., 1990; Rogers, 2003).

Third, the ability to support and train employees in the adoption and use of XR has been recognized as crucial factor, as these capabilities can help an organization overcome problems in XR use and reduce resistance (Chandra & Kumar, 2018; Jalo et al., 2022). Fourth, a lack of employee XR skills has been suggested as a key hindrance for XR adoption (Badamasi et al., 2022; Davila Delgado et al., 2020). More broadly, employees' IT experience has been found to be positively associated with the adoption of new technologies (Jeyaraj et al., 2006). These antecedents emphasize the *organizational factors* affecting XR resistance and adoption (DePietro et al., 1990).

Fifth, the ability to obtain support from external sources can help organizations solve challenges with XR, as XR expertise is still often lacking in many industries (Davila Delgado et al., 2020). Sixth, pressure from competitors, also known as mimetic pressure, was found to be the single most important factor explaining the adoption of virtual worlds (Yoon & George, 2013). Mimetic pressure has also been suggested to be important in the XR adoption context (Jalo et al., 2022). These antecedents can be described as *environmental factors* affecting XR resistance and adoption (DePietro et al., 1990).

The effects of these technological, organizational, and environmental antecedents are described in more detail in the hypotheses section.

3. Mixed methods research design

A sequential mixed-methods design combining a cross-sectional quantitative survey and qualitative semi-structured interviews was chosen for our study (Venkatesh et al., 2013). As both the quantitative and qualitative studies relied on cross-sectional data, establishing direct causality between the examined variables can be difficult (Maier et al., 2023). We followed the recommendations of Maier et al. (2023) and integrated the findings from the different research strands to partially mitigate such limitations. Following prior examples, we first aimed to establish the significance and direction of the variable relationships quantitatively, and second, to provide a deeper understanding about the dynamics of those relationships through qualitative insights (Maier et al., 2023; Venkatesh et al., 2013).

As the first step, a quantitative survey (Study 1) was conducted to confirm the significance of expected employee resistance in organizational adoption dynamics. Study 1 proposes a research model based on 12 hypotheses and tests the model using the SEM approach with a cross-sectional survey sample of European industrial decision makers ($n = 206$). To provide richer explanations about the dynamics of the validated theoretical model of Study 1, a qualitative Study 2 based on 58 semi-structured interviews with European industrial managers was carried out (Gable, 1994; Jick, 1979; Kaplan & Duchon, 1988). An interpretive approach was selected for the second part of this mixed-methods study to provide a more in-depth understanding of the manifestations of XR adoption in companies and to identify key conditions affecting the relationships between the examined dependent variables of the SEM model in Study 1 (Jick, 1979; Zachariadis et al., 2013).

4. Study 1: quantitative model development and testing

4.1. Research model and hypotheses

Based on the value-risk organizational adoption model (Gao et al., 2012) and user resistance literature (Kim & Kankanhalli, 2009), we propose a research model in which the perceived organizational value of XR positively influences organizational XR adoption intention, and conceptualize expected employee resistance to XR adoption as a specific adoption risk, which negatively influences both the perceived organizational value of XR and the organization's intention to adopt XR. Moreover, the TOE framework (DePietro et al., 1990) is used to extend the model with critical factors that either enhance organizational value perceptions or mitigate the expected level of employee resistance. The synthesized research model is presented in Fig. 1. Next, we expand on the hypotheses included in the model.

4.1.1. Effects of managerial expectations of employee resistance to XR and the perceived organizational value of XR on organizational XR adoption intention

XR adoption can bring radical changes to employees' work activities, such as moving from face-to-face collaboration to remote AR collaboration (Jalo et al., 2018; Porter & Heppelmann, 2017) or remote VR design reviews (Torro et al., 2021; Wolfartsberger, 2019), leading to significant changes in previous social and organizational structures. Employees may feel threatened by these changes or think that they will lose something if they switch to using XR (Kim & Kankanhalli, 2009; Markus, 1983). With novel and relatively technologically immature solutions, such as XR, the transition and uncertainty costs for employees are also likely higher than with well-established technologies that are still not in use in an organization (Kim & Kankanhalli, 2009). Despite any other risks in adopting a technology, the potential for resistance from employees is paramount, as an unused system cannot bring value to an organization. If managers believe employees will strongly resist using XR—either overtly or covertly—or even encourage others not to use it (Lapointe & Rivard, 2005), this will likely negatively influence organizational decision makers' propensity to push for adopting XR, as

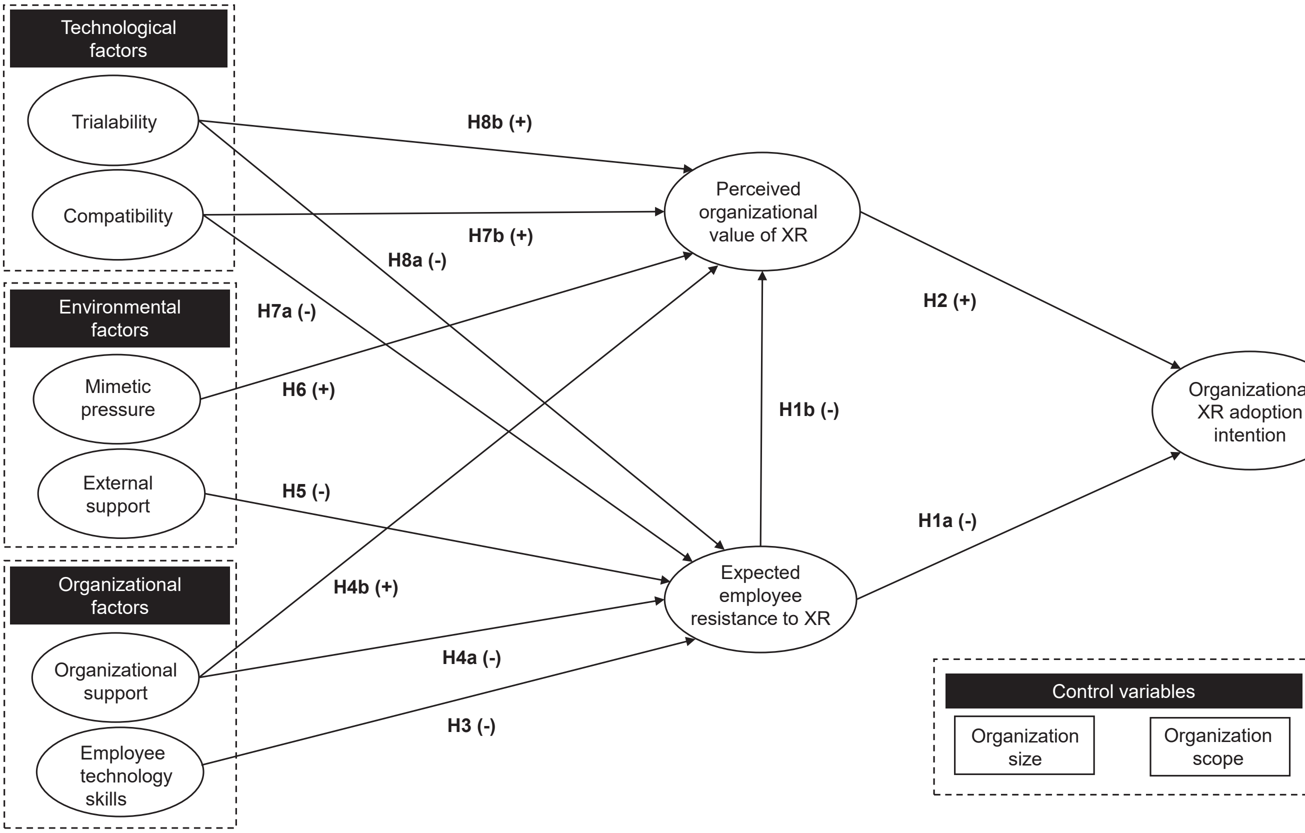

Fig. 1. Proposed research model.

overcoming such resistance is especially challenging (van Offenbeek et al., 2013). These types of beliefs are likely to negatively influence an organization's eagerness to adopt such technologies. Thus, we hypothesize that the expected resistance from employees is negatively associated with an organization's intention to adopt XR.

Hypothesis 1a. (H1a): Expected employee resistance to XR is negatively associated with an organization's intent to adopt XR.

Mitigating and overcoming user resistance requires time, resources, and effort from managers (Ilie & Turel, 2020; Markus, 1983). Influencing efforts needed in changing the perceptions of employees relating to a technology may, for instance, require coalition building and rational persuasion regarding a technology's benefits, and in some cases, managers may even resort to direct pressuring tactics (Ilie & Turel, 2020). Each of these comes with its own resource costs (e.g., to the manager's time and allotted budget) and possibly even social costs (e.g., credibility loss for the manager if the influencing efforts fail). Therefore, when managers deem user resistance to be a challenging yet surmountable issue, expected employee resistance to XR adoption will likely play a key role when decision makers weigh the potential benefits and costs of adoption, and consequently, the overall value of XR for their organization (Gao et al., 2012; Kim & Kankanhalli, 2009). We thus hypothesize that expected employee resistance to XR is negatively associated with managers' perceived value of XR for the organization:

Hypothesis 1b. **(H1b):** Expected employee resistance to XR is negatively associated with the perceived organizational value of XR.

Our second hypothesis suggests that the value of XR for an organization (as perceived by decision makers) is associated with the organization's adoption intention, as managers and senior decision makers are often drivers and champions for change and the use of novel technologies in organizations (Berg & Vance, 2017; Vagnani & Volpe, 2017). As managers are often rewarded for increasing the efficiency and competitiveness of their company, the value that a new technology can bring to the company will likely be at the forefront as they evaluate the adoption of a new technology. Moreover, as perceived value encompasses an overall evaluation of the benefits and costs of a technology (Gao et al., 2012; Kim & Kankanhalli, 2009), it is expected to have a direct proximate relationship with an organization's intention to adopt XR. As organizations' perceptions of the potential of XR to create time and cost savings have been increasing steadily in recent years (Noghabaei et al., 2020), we expect this factor to have a primary influence on organizational XR adoption intention. Thus, we hypothesize the following:

Hypothesis 2. (H2): The perceived organizational value of XR is positively associated with an organization's intent to adopt XR.

4.1.2. Organizational antecedents of expected employee resistance and perceived organizational value

The number of XR experts employed by organizations, as well as their level of expertise, has been increasing significantly in recent years (Noghabaei et al., 2020). However, the overall skill level with XR is still low in many industries, which has also been identified as a key barrier to XR adoption (Badamasi et al., 2022; Davila Delgado et al., 2020). As user experience with IT has been found to be a significant predictor of individual adoption of IT solutions (Fink, 1998; Jeyaraj et al., 2006), decision makers are also likely to evaluate whether their employees' existing skills and capabilities are sufficient to use XR solutions effectively, as this will make the adoption process easier for the organization. Preexisting skills can increase the employee's self-efficacy for change, which has been found to be negatively associated with user resistance (Kim & Kankanhalli, 2009). This is because employees perceive the associated adoption switching costs as lower when they believe in their ability to independently handle challenges (Kim & Kankanhalli, 2009). Accordingly, having employees who are already skilled in using XR, regardless of whether these capabilities stem from professional or hedonic use (Jalo et al., 2020), is likely associated with lower levels of user resistance.

As XR gaming and entertainment still constitute the largest segments in the overall XR market (Statista, 2019), extant XR user skills are also likely to stem from the consumer context. Consequently, these existing skills are likely to impact the users' inclination and eagerness toward using professional XR solutions. However, given that these skills will still require adaptation and development to suit the professional context, the influence of existing user skills is more likely to predominantly shape managerial expectations of employee resistance rather than the perceived organizational value of XR. Due to these reasons, we only hypothesize employees' user skills to be related to expected employee resistance, rather than perceived value. Thus, as the overall XR use capabilities and skills of employees increase in the organization, we hypothesize that the level of expected employee resistance to XR adoption will decrease, as XR will not be viewed as being as complex and difficult to use (Vagnani & Volpe, 2017):

Hypothesis 3. (H3): An organization's employees' XR technology use skills are negatively associated with expected employee resistance to XR.

The availability of organizational support for users is a significant factor for individuals when adopting or resisting a technology (Jeyaraj et al., 2006; Kim & Kankanhalli, 2009). The capability of an organization to support its employees can manifest in various forms, for instance, as internal champions (Berg & Vance, 2017) or as distinct tech support functions (Sykes, 2015). The existence of a champion who can demonstrate a technology's usefulness and mitigate potential problems related to the technology is critical for adopting XR solutions (Berg & Vance, 2017; Jalo et al., 2020, 2022). Kim and Kankanhalli (2009) also found that the level of organizational support had a direct mitigating effect on individual user resistance to enterprise system adoption. An organization's technical capabilities are also crucial in the sense that by avoiding technical problems, the organization will be better able to focus on solving the human and other organizational issues that arise during adoption (Markus, 2004). Thus, we hypothesize that organizational support capabilities are negatively associated with expected employee resistance to XR, as managers will likely estimate that an organization's employees will resist a technology less if the organization can readily offer support for its adoption and use:

Hypothesis 4a. **(H4a):** An organization's capabilities to support its employees in XR adoption and use are negatively associated with expected employee resistance to XR.

Moreover, existing organizational support capabilities will likely also affect managerial calculations relating to the potential overall value that can be gleaned from a technology. If the organization is able to provide the needed support independently and adapt their XR solutions without the need for external consultants or vendor support, the overall value will increase as extant internal resources can be used to solve problems and expand the use of XR without additional costs from using external support assets (Dwivedi et al., 2022; Yoo et al., 2023). Moreover, internal capabilities in creating company-specific XR content will similarly skew the value calculus in a positive direction (Berg & Vance, 2017; Dwivedi et al., 2022). Organizational competence in handling 3D models will also speed up internal business processes and workflows, as the models that are used in the XR solutions do not have to be sent to external companies for visualization and optimization purposes (Jalo et al., 2020, 2022). Thus, we hypothesize that organizational support capabilities are positively associated with higher levels of perceived organizational value, as organizations can more easily use and adapt these solutions for various purposes without external support:

Hypothesis 4b. **(H4b):** An organization's capabilities to support its employees in XR adoption and use are positively associated with the perceived organizational value of XR.

4.1.3. Environmental antecedents of perceived user resistance and perceived value

Although external support has found mixed evidence regarding its impact on technology adoption, we expect the distinct nature of XR—for example, its higher levels of immersion, presence, and interactivity (Mütterlein & Hess, 2017) and novel interaction methods (Wolfartsberger, 2019)—to require external adoption support in many organizations. Research by Davila Delgado et al. (2020) also suggests that external expert support and advice should be easily available for organizations to help them choose the right equipment and overcome the possible complexity in integrating different IS and software with XR. Small and medium-sized enterprises (SMEs) also often need external support when adopting new technologies, as they are less likely to have in-house tech support functions (Fink, 1998; Igbaria et al., 1997). Certain types of XR solutions, such as tethered VR HMDs, can also be difficult for users to install and maintain (Jalo et al., 2020).

These types of compatibility difficulties and complex troubleshooting issues can thus be expected to be related to higher levels of expected resistance from employees. If problems related to XR cannot be solved internally, and obtaining external assistance is either difficult or impossible, employees are likely to feel apprehensive about adopting XR and thus potentially resist its adoption. Moreover, given that obtaining external support usually leads to increased costs for the organization, and thus does not inherently increase the value of XR, external support is likely to predominantly affect managerial perceptions relating to expected resistance rather than organizational value. This is why we do not hypothesize external support to have an effect on perceived value, but rather only on expected employee resistance. Thus, our hypothesis is as follows:

Hypothesis 5. **(H5)**: External support is negatively associated with expected employee resistance to XR.

The positive and negative experiences of an organization's competitors with a technology are significant determinants of organizational adoption intention (Jeyaraj et al., 2006; Yoon & George, 2013) and perceived value (Gao et al., 2012). Competitors' experiences with a technology are thus a pertinent factor affecting managerial value perceptions. Institutional theory characterizes this type of external influence as mimetic pressure (Liang et al., 2007; Teo et al., 2003; Yoon & George, 2013). As XR technologies are still unfamiliar to many organizations, decision makers may want to mimic other organizations that are successfully using XR to mitigate the competitive advantage achieved by their competitors (DiMaggio & Powell, 1983; Gao et al., 2012; Liang et al., 2007). Mimetic pressures positively affect top management beliefs (Liang et al., 2007), as they can make technology appear more legitimate (Son & Benbasat, 2007; Teo et al., 2003). Additionally, the effect of mimetic pressures appears to be especially strong with technologies that are perceived to be complex (Teo et al., 2003), which can be argued to be the case with XR. Moreover, mimetic pressures are likely to primarily influence value perceptions rather than expected employee resistance, as employees are unlikely to pay as much attention to the types of technologies utilized by other companies. This is why we only hypothesize it to be related to the perceived organizational value of XR. Thus, we hypothesize the following:

Hypothesis (H6). : Mimetic pressure is positively associated with the perceived organizational value of XR.

4.1.4. Technological antecedents of expected employee resistance and perceived organizational value

Empirical evidence on the role of compatibility in the adoption of technologies has been inconsistent (Jeyaraj et al., 2006). However, due to the frequently mentioned challenges in integrating various IS with XR (e.g., Du et al., 2018; Jalo et al., 2018, 2020, 2022; Masood & Egger, 2019), their examination appears warranted within the XR context. As XR technologies are seen as novel interfaces for interacting with digital

3D content (Davila Delgado et al., 2020; Steffen et al., 2019), the ease of bringing these models into XR is thus a crucial factor for the everyday use of XR technologies, as people prefer technologies that are easy to use (Jeyaraj et al., 2006). Compatibility challenges can also lead to people venting out their frustrations explicitly if they feel like they cannot handle their allotted work responsibilities (Pirkkalainen et al., 2019), which can lead to a negative work atmosphere and further resistance in other employees, as colleague opinions have been shown to influence resistance behaviors (Kim & Kankanhalli, 2009). If the employees feel that they are incapable of controlling their devices (as might be the case with unexplainable incompatibility issues), they will likely resort to venting out their feelings of distress openly (Pirkkalainen et al., 2017). If XR is perceived as compatible with organizational IS, the expected level of resistance from employees is likely to be lower because of lower levels of difficulty and related frustrations with XR and IS workflows. Thus, our hypothesis is as follows:

Hypothesis 7a. **(H7a):** The compatibility of XR with organizational information systems is negatively associated with expected employee resistance to XR.

Previous research has also highlighted the need to examine how technology characteristics, including compatibility, affect the value perception of radical and discontinuous technologies (Gao et al., 2012). Extant literature has also suggested that an important part of the organizational value of XR stems from its ability to display digital content to users in novel ways (Porter & Heppelmann, 2017; Torro et al., 2021). However, the workflows between IS and software and XR have been found to be time consuming in many industry contexts (Du et al., 2017; Jalo et al., 2020, 2022), which can make XR use in business processes cumbersome. Thus, if managers perceive XR to be highly compatible with XR, they are also likely to perceive its value as higher for the organization because of the ease of adoption and the ability to use XR in work tasks more fluently. Compatibility is also associated with higher levels of net benefits, as less effort is required to integrate the new solution into existing technologies (Vagnani & Volpe, 2017). Thus, we hypothesize the following:

Hypothesis 7b. **(H7b):** The compatibility of XR with organizational information systems is positively associated with the perceived organizational value of XR.

Although evidence for the effect of trialability on adoption has been mixed (Tornatzky & Klein, 1982; Vagnani & Volpe, 2017), some studies have found that companies with a greater ability to experiment with new enterprise systems are more likely to adopt them (Ramdani et al., 2009). Given the unique characteristics of XR and its novelty (Mütterlein & Hess, 2017; Porter & Heppelmann, 2017), XR can also face resistance from those who are unfamiliar with it. Therefore, if employees can easily test out new XR technologies before they are implemented in the organization, the level of resistance is likely to be lower, as the technology will not be as unfamiliar to them at that stage. In addition, the ability to test the devices also entails the possibility of employees changing their perceptions and opinions about the technology for the better if the initial testing opportunities are facilitated effectively and the technology works smoothly (Jalo et al., 2022; Selander & Henfridsson, 2012). Moreover, including users in the adoption process from the start can enable the company to better consider their concerns and improvement ideas (Ali et al., 2016), thus mitigating potential sources of resistance even before the technology is actually implemented in the organization. This participatory approach can also help the employees feel like they have a vested interest in the implementation of the system (Henry, 1994). Rather than having to rely on the employees' imagination, practical experiences with the technology can also help the employees better evaluate what value the technology might bring to their daily work and how it might improve their performance (Ali et al., 2016; Lapointe & Rivard, 2005), which may make them more receptive to using the technology. Thus, our hypothesis is as follows:

Hypothesis 8a. **(H8a):** The trialability of XR is negatively associated with expected employee resistance to XR.

Trialability is also crucial in terms of determining the value of a technology for an organization, as it can enable the identification of hardware that is more suitable for specific organizational contexts in terms of performance and ease of use (Jalo et al., 2020, 2022). We thus expect that organizations will need to be able to try out different XR solutions to evaluate their usefulness. As XR technologies are still new to many employees, higher levels of trialability can also help managers assess potential issues and the overall value of XR before implementing the technology (Vagnani & Volpe, 2017). The ability to try out the technology before adoption can also assist the organization in ensuring its alignment with user demands. This can potentially prevent expensive redesign and redevelopment efforts by fostering alignment among developers, implementers, and end users from the outset (Ali et al., 2016; Ives & Olson, 1984). Pre-adoption trials can also enhance top management's understanding of its potential, thereby aiding in securing resources for XR adoption. This has consistently been shown to be one of the strongest predictors of technology adoption within organizations (Jeyaraj et al., 2006; Ramdani et al., 2009). Thus, our hypothesis is as follows:

Hypothesis 8b. **(H8b):** The trialability of XR is positively associated with the perceived organizational value of XR.

4.1.5. Control variables

We included organization size as a control variable because it has been found to be a significant factor in the organizational adoption of IT and IS (Jeyaraj et al., 2006; Ramdani et al., 2009), particularly in relation to cutting-edge and discontinuous technologies (Dewar & Dutton, 1986). In addition, the organization's operating scope (local, national, and global) was included as a control variable because many XR use cases emphasize remote collaboration (Lounakoski et al., 2022; Porter & Heppelmann, 2017; Torro et al., 2021). As these kinds of activities are likely more common among organizations that operate globally, we wanted to control for this effect. Organizations that operate more globally typically also face higher coordination costs and are thus more likely to adopt technologies that can help mitigate these problems (Zhu et al., 2003).

4.2. Survey data collection

Data for the validation of the research model were collected via a survey. The survey was carried out online via SurveyGizmo (now called Alchemer) between April 2020 and October 2020. The data were collected in the context of a European research project on XR with research partners from nine EU countries. We targeted the data collection on managers and decision makers of European industrial companies. The data were collected by distributing the survey in the research partners' networks. This allowed us to collect a wide-ranging sample from European industrial companies with diverse backgrounds representing multiple industrial sectors. This helped reduce possible biases in our results, as the sample was not focused on a single country or industry.

The survey used existing and validated scales from the literature, which were adapted and rephrased to fit the research context. The adapted scales and their sources can be found in Appendix C (Table C1). We used a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly disagree) to measure the items. An attention-trap question was included to help identify possibly inattentive respondents. The survey was first implemented in English and then translated into Spanish, Italian, and German. The translations were carried out in two steps, in which a native speaker first translated the survey into each language, and these translations were then contrasted and confirmed against the original English version by another native speaker.

As we were interested in the perceptions of organizational decision makers regarding factors affecting the adoption of XR, using self-reported measures was deemed to be appropriate (Conway & Lance, 2010). When using self-reported measures, common method variance (CMV), that is, systematic variance resulting from the measurement method (Simmering et al., 2015), is a potential threat to the validity of the results and should thus be proactively mitigated (Conway & Lance, 2010). We used several ex ante procedural remedies and survey design techniques to mitigate CMV beforehand (Podsakoff et al., 2003). First, we informed the respondents that their answers were anonymous, and that the data would be used only for research purposes (Podsakoff et al., 2003). Second, we separated the independent and dependent variables into separate sections in the survey design (Podsakoff et al., 2012). The order of the items was also randomized for each respondent so that the respondents would not feel pressured to answer consecutive similar questions identically (Nederhof, 1985). We also had two professors with extensive experience in survey research evaluate the survey for its content validity. This helped us to identify and refine any unclear phrasings, thus decreasing ambiguity in the items (Podsakoff et al., 2012). These were also further improved for clarity after the survey was pilot tested with two companies in Finland and Italy. We also tested for CMV ex post (see Section 4.3.4).

The survey was divided into four parts. First, the examined technologies (AR and VR) were defined to the respondents as per the definitions included in Section 2.1. Second, background information was collected about the respondents and the companies they represented. Third, the respondents were asked which between AR and VR they felt had more potential for their organization. Overall, 129 respondents felt that AR had more potential than VR for their company, whereas 77 chose VR. In the final part, the respondents were asked to answer the statements (listed in Appendix C, Table C1) with that technology in mind. The respondents were asked to consider the future adoption of their chosen XR technology in their company. In case the respondents' companies were already using XR to some degree, they were instructed to consider the future organizational prospects of the technology.

In total, we received 213 complete responses, which were screened in multiple steps, resulting in 206 valid responses. We excluded 1 response from South Africa, as it was from outside of Europe, and removed 6 responses for inattentive responding (< 0.5 sd in the responses) or for responding at a speed that would be impossible to do attentively (< 5 min). The sample was then examined for missing data. We found two missing values for USE_3 (see Appendix C, Table C1), which were imputed with the median value of the item. Finally, we screened the remaining responses that failed the attention-trap question. We found sufficient variance in their answers, and the respondents took a sufficiently long enough time (> 10 min) to complete the survey. Demographic information about the respondents (n = 206) can be found in Table 1. As can be seen from the table, the survey responses were collected from top management (61), middle management (65), lower management (51), and experts (29). Table 2 depicts information about the companies of the respondents.

We also carried out an a priori statistical power analysis to determine the minimum recommended sample size based on the complexity of our model (Maier et al., 2023). We used the calculator provided by Soper (2022) for the analysis, which calculates the recommended minimum sample size given the specifics of the model based on the formula developed by Westland (2010). Our research model had 9 latent constructs and 27 observed variables (see Appendix C). For the calculation, we used a medium effect size (0.3), a minimum suggested power level of 0.8 (Cohen, 1988), and a probability level of 0.05, resulting in a minimum recommended sample size of 200, which is satisfied by our sample (n = 206), suggesting adequate power for the results.

4.3. Survey data analysis and results

IBM SPSS Statistics version 27 was used for data screening, descriptive statistics, and the initial exploratory factor analysis (EFA) of the data. We used IBM Amos version 27 for the confirmatory factor analysis (CFA) and the SEM analysis. Amos was chosen over partial least squares (PLS) tools as the model fit measures (specifically comparative fit index, CFI and root mean square error of approximation, RMSEA) required in the configural and metric invariance tests—which are used to ascertain whether the AR and VR responses can be analyzed together—were not available in PLS (Chen, 2007). The more extensive model fit statistics offered by Amos were also needed in more robustly testing the proposed theoretical model to minimize the risk of making incorrect inferences (Dash & Paul, 2021; Kline, 2015; Rönkkö et al., 2016). Moreover, as our model included latent constructs (rather than formative or composite constructs) dealing with the managers' beliefs and attitudes, which constitute a common factor model, we chose to use Amos (covariance-based SEM) rather than PLS (variance-based SEM) as it has been argued to perform better in such situations (Dash & Paul, 2021; Evermann & Rönkkö, 2023).

Table 1
Demographics of the survey respondents (n = 206).

	Frequency	%
Gender		
Male	165	80.1 %
Female	41	19.9 %
Age (years)		
18–24	8	3.9 %
25–34	57	27.7 %
35–44	53	25.7 %
45–54	54	26.2 %
55–64	32	15.5 %
65–74	2	1.0 %
Education		
Less than high school	1	0.5 %
Graduated high school	7	3.4 %
Trade/technical school	10	4.9 %
Some college, no degree	8	3.9 %
Associate degree	5	2.4 %
Bachelor's degree	47	22.8 %
Advanced degree (Master's, Ph.D., M.D.)	128	62.1 %
Organizational position		
Lower management (e.g., project manager)	51	24.8 %
Middle management (e.g., department manager)	65	31.6 %
Top management (e.g., chief technology officer)	61	29.6 %
Other (e.g., experts)	29	14.1 %

4.3.1. Sampling adequacy, factor loadings, normality, outliers, and multicollinearity

We first tested the data for sampling adequacy with the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity in SPSS. Both the KMO measure (0.850, above the suggested 0.7 cutoff) and Bartlett's test ($\chi 2(378) = 3932{,}406$, $p < 0.001$) suggested sufficient correlations between items in the sample for factor analysis (George & Mallery, 2019). We subsequently examined the factor loadings of the adapted scale items to confirm that the items loaded into their expected constructs (Table B1, Appendix B). We employed the principal axis factoring method and promax rotation to derive the pattern matrix, as recommended in literature (Matsunaga, 2010). With a sample size of over 200, Hair et al. (2014) suggest that a minimum factor loading of 0.4 should be used as the cutoff. As can be seen from the table, all of the items loaded into their anticipated constructs with high loadings (> 0.6) and the items did not have any strong cross-loadings (< 0.2) with other constructs (George & Mallery, 2019). Next, we checked the data for normality. The kurtosis and skewness values for the items fell between −2 and +2, suggesting sufficient normality in our data (George & Mallery, 2019). We also did not have any outlier respondents with a Cook's distance of over 1 (Cook & Weisberg, 1982) or issues with multicollinearity, as all of the variance inflation factors for the constructs were below 5 (Sheather, 2009).

Table 2
Information about the respondents' companies (n = 206).

	Frequency	%
Operating area		
Locally	26	12.6 %
Locally and nationally	60	29.1 %
Locally, nationally, and globally	120	58.3 %
Location		
Austria	24	11.7 %
Belgium	25	12.1 %
Cyprus	26	12.6 %
Estonia	11	5.3 %
Finland	28	13.6 %
Germany	20	9.7 %
Greece	2	1.0 %
Ireland	1	0.5 %
Italy	17	8.3 %
Netherlands	22	10.7 %
Romania	1	0.5 %
Spain	29	14.1 %
Employees		
1–9	38	18.4 %
10–49	67	32.5 %
50–250	52	25.2 %
251–500	13	6.3 %
501–1000	5	2.4 %
> 1000	31	15.0 %
Industry		
Aerospace	6	2.9 %
Architecture and construction	28	13.6 %
Automotive and vehicles	14	6.8 %
Biotechnology	1	0.5 %
Chemicals	3	1.5 %
Clothes and textiles	1	0.5 %
Computers and electronics	16	7.8 %
Electrical equipment	3	1.5 %
Food and beverages	7	3.4 %
Furniture	3	1.5 %
Healthcare and pharmaceuticals	14	6.8 %
Industrial installation and maintenance	11	5.3 %
Machinery and equipment	21	10.2 %
Metals	19	9.2 %
Plastics	2	1.0 %
Other (e.g., consulting)	53	25.7 %
Primary customers		
Businesses and companies	123	59.7 %
Consumers	33	16.0 %
Distributors/agents/dealers	10	4.9 %
Governmental institutions	5	2.4 %
Higher education or research institutes	9	4.4 %
Public organizations (e.g., schools, hospitals)	12	5.8 %
Other	14	6.8 %

4.3.2. *Convergent and discriminant validity analysis*

We then proceeded with the CFA by evaluating the fully correlated measurement model. As the first step in assessing the indicator and construct validities, we examined the standardized item loadings for the constructs. All loadings were statistically significant ($p < 0.001$) and above the recommended 0.707 threshold (Fornell & Larcker, 1981), except for one RESI item, which had a loading of 0.689. Thus, this item was dropped from subsequent analyses. The constructs, items, and their means, standard deviations, and standardized factor loadings are presented in Appendix C (Table C1).

Next, we used the Master Validity plug-in of Gaskin et al. (2019) to analyze the discriminant validity of our measurement model (Table 3). According to Fornell and Larcker (1981), the composite reliability (CR) value of all constructs should be above 0.7, the average variance extracted (AVE) should be above 0.5 and larger than the maximum shared variance (MSV), and the square root of each AVE should be larger than all other correlations with the other variables. The CR, AVE, MSV, and square root of the AVE (bolded in diagonal) are reported in Table 3. As can be seen, our data fit all the aforementioned criteria, indicating sufficient convergent and discriminant validity for our model.

In our discriminant validity analysis, we also employed heterotrait-monotrait (HTMT) ratio of correlations analysis, which can detect discriminant validity issues reliably and consistently (Franke & Sarstedt, 2019; Henseler et al., 2015; Voorhees et al., 2016). The recent methodology literature also recommends using HTMT to achieve more stringent discriminant validity results, as the traditional comparison of average variance extracted to shared variance (AVE-SV) approach by Fornell and Larcker (1981) has limitations in detecting discriminant validity issues (Henseler et al., 2015; Rönkkö & Evermann, 2013). We used the Gaskin et al. (2019) Amos plugin to carry out the HTMT analysis. The results in Table 3 (right side of the bolded diagonal) suggest no discriminant validity issues in our model, as none of the inter-construct correlations were above the strict cutoff criteria of 0.850 (Henseler et al., 2015), which has also been shown to provide the best balance for detection rates and false positives (Voorhees et al., 2016). Overall, our measurement model had no significant discriminant validity issues.

4.3.3. *Configural and metric invariance*

To establish that AR and VR can be analyzed conjointly, we had to eliminate the potential concern that the AR and VR respondents differed significantly in how they answered the survey. Thus, we needed to assess the overall measurement model invariance for AR and VR respondents by testing for configural and metric invariance to examine whether the factor structure was equivalent for both technologies (Milfont & Fischer, 2010; van de Schoot et al., 2012). We assessed the invariances between the configural and metric models by examining the differences in CFI, RMSEA, and standardized root mean residual (SRMR) between the models, as these measures are not as sensitive to sample size or model complexity as the traditionally used chi-square test (Chen, 2007; van de Schoot et al., 2012). We used the cutoffs of $\Delta CFI \leq -0.005$, $\Delta RMSEA \geq 0.01$, and $\Delta SRMR \geq 0.025$, as suggested by Chen (2007), to test whether the models were invariant.

Configural invariance was tested by freely estimating a model with two groups (AR, n = 129 and VR, n = 77). The model still had an acceptable or excellent fit with the data (CFI = 0.926, RMSEA = 0.048, with a PClose of 0.636, SRMR = 0.0628; Hair et al., 2014), indicating

Table 3
Reliability and validity results (Fornell and Larcker criterion results on the left side of the bolded diagonal, HTMT results reported on the right side of the bolded diagonal).

	CR	AVE	MSV	USE	EXSU	RESI	ETUS	COMP	ORSU	MIME	TRIA	VALU
USE	0.932	0.821	0.361	**0.906**	0.364	0.412	0.538	0.331	0.609	0.392	0.318	0.631
EXSU	0.877	0.704	0.152	0.375***	**0.839**	0.208	0.400	0.327	0.290	0.185	0.309	0.147
RESI	0.861	0.675	0.328	0.387***	0.230**	**0.821**	0.544	0.270	0.564	0.106	0.358	0.388
ETUS	0.895	0.741	0.284	0.514***	0.389***	0.517***	**0.861**	0.278	0.560	0.253	0.176	0.279
COMP	0.911	0.774	0.197	0.316***	0.327***	0.283***	0.279***	**0.880**	0.443	0.069	0.309	0.193
ORSU	0.852	0.657	0.348	0.590***	0.282***	0.573***	0.533***	0.444***	**0.810**	0.240	0.330	0.407
MIME	0.867	0.687	0.201	0.374***	0.165*	0.101	0.224**	0.052	0.207*	**0.829**	0.188	0.462
TRIA	0.837	0.632	0.128	0.312***	0.310***	0.358***	0.157†	0.303***	0.335***	0.160†	**0.795**	0.314
VALU	0.881	0.711	0.361	0.601***	0.145†	0.384***	0.265**	0.199*	0.414***	0.448***	0.306***	**0.843**

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.1$

good configural invariance. The respondents thus conceptually understood the items similarly (Chen, 2007; Milfont & Fischer, 2010), whether they answered them in the context of AR or VR. Next, we tested for metric invariance between the groups by constraining the regression weights from the constructs to the items to be equal. The CFI (0.924, ΔCFI = −0.002), RMSEA (0.048, ΔRMSEA = 0.000), and SRMR (0.0657, ΔSRMR = 0.0029) were within the suggested cutoffs, indicating that the item factor loadings were similar for both AR and VR (Milfont & Fischer, 2010). Metric invariance was thus also established, indicating that AR and VR can be analyzed conjointly within our sample.

4.3.4. Common method variance

As the data were based on self-reporting, and the independent and dependent variables were collected with the same survey, we also examined the sample for CMV to ascertain whether issues such as social desirability or acquiescence bias might have introduced systematic bias into the responses (Podsakoff et al., 2003). First, the existence of both positive and negative correlations within our data (negative with RESI and other constructs, positive between all other constructs) suggests that CMV was not a significant issue, at least when it comes to acquiescence bias, that is, the respondents' tendency to agree with all the survey statements (Podsakoff et al., 2003).

Second, a marker test variable was included in the survey a priori to test for CMV (Williams et al., 2010). The marker used the same measurement scale and anchors as the other items, as recommended by Richardson et al. (2009). The three-item construct (1: "When I must choose between the two, I usually dress for fashion, not for comfort."; 2: "An important part of my life and activities is dressing smartly."; 3: "A person should try to dress in style.") focused on the respondent's fashion consciousness (FC) and was thus theoretically unrelated to the other constructs (Malhotra et al., 2006). The FC construct also measured the respondent's perceptions instead of factual characteristics (such as age) and should thus be susceptible to CMV, similar to the theoretical constructs (Richardson et al., 2009; Simmering et al., 2015). The same FC construct has also been used in extant IS literature (see e.g., Malhotra et al., 2006; Pirkkalainen et al., 2019), attesting to its applicability.

We proceeded with the marker test by first estimating an initial CFA model, where the marker variable was correlated with the other theoretical constructs to determine the unstandardized factor loadings and error variances for the marker variable for the later models. Correlations between FC and other constructs ranged from −0.132 with RESI to 0.215 with EXSU, and the mean absolute correlation was 0.107, which is in line with other studies (Malhotra et al., 2006). Next, a baseline model was created where the marker variable was not connected with the other model indicators. The marker variable's item regression weights and error variances were fixed with the values obtained from the initial CFA model. Next, a Method-C model was created where equally constrained loadings were set between the marker variable and the other model indicators. A comparison between the baseline model ($\chi2 = 547.5$, df = 374) and the Method-C model ($\chi2 = 547.3$, df = 373) suggested that the method-C model did not fit the data better ($p = 0.655$), indicating no significant CMV in the model. Therefore, we can conclude that CMV is not a significant threat to the validity of our results.

4.3.5. Model fit

We opted to evaluate the model fit for the measurement and path models using the CFI, SRMR, and RMSEA measures. This is in line with the recommendations of Hair et al. (2014), who suggested that model fit should be evaluated with at least one absolute fit measure (e.g., SRMR and RMSEA) and one incremental fit index (e.g., CFI). The suggested cutoffs for these fit measures are ≥ 0.95 for CFI, ≤ 0.08 for SRMR, and ≤ 0.08 for RMSEA, along with > 0.05 for its PClose (Hair et al., 2014). As shown in Table 4, the measurement model's values were excellent for all of these fit indices. The model's normed chi-square ($\chi2/df$) was 1.515, which falls within the suggested range of 1–3 (Hair et al., 2014). The chi-square test was statistically significant ($p < 0.05$), indicating poor fit with the data; however, this is common with complex models and larger sample sizes (Schermelleh-Engel et al., 2003). Moreover, Hair et al. (2014) recommend that this measure should not be examined independently but in the context of other model fit measures. As all the other model fit indices were excellent, we can conclude that the measurement model fit the data well. After we moved on to the hypothesis-testing phase, we also evaluated the path model's fit. Again, the measures were still excellent except for CFI (0.946), which was still close to excellent fit, but within acceptable range (≥ 0.9) nonetheless.

Table 4
Model fit for the measurement and path models.

Measure	Measurement model	Path model
χ2	436.214	530.771
df	288.000	333.000
χ2/df	1.515	1.594
CFI	0.959	0.946
SRMR	0.050	0.071
RMSEA	0.050	0.054
PClose	0.483	0.227

4.3.6. Hypothesis testing

After the measurement model's fit and validity were established, we moved to the path testing of our research model. The latent constructs were maintained in Amos instead of creating imputed sum constructs. The variances explained (R^2) by the model in the dependent variables were 40 % for perceived organizational value of XR, 46 % for expected employee resistance to XR, and 44 % for organizational XR adoption intention. The overall hypothesis testing results can be seen in Fig. 2.

Four out of twelve of the paths were significant at the $p < 0.001$ level, two at the $p < 0.01$ level, and one at the $p < 0.05$ level. Seven out of the twelve hypotheses were thus supported (see Table 5). For the statistically significant paths, the effect directions (positive or negative) were as hypothesized in the research model (Fig. 1). Thus, the research model had overall empirical support.

Regarding the direct antecedents influencing XR adoption intention, perceived organizational value of XR was found to be positively associated with organizational XR adoption intention ($\beta = 0.539$; $p < 0.001$), and expected employee resistance to XR was negatively associated with organizational XR adoption intention ($\beta = -0.234$; $p < 0.01$). Expected employee resistance to XR was also negatively associated with the perceived organizational value of XR ($\beta = -0.189$; $p < 0.05$). Hypotheses H1a, H1b, and H2 were thus supported.

Both of the organizational antecedents, namely, organizational support capability ($\beta = -0.376$; $p < 0.001$) and employee technology use skills ($\beta = -0.297$; $p < 0.001$), were negatively associated with expected employee resistance to XR, supporting hypotheses H3 and H4a. External support and compatibility were not negatively associated with expected employee resistance to XR in a statistically significant way. Thus, H5 and H7a were not supported by the data. Trialability was also shown to have a negative relationship with expected employee resistance to XR ($\beta = -0.200$; $p < 0.01$), supporting H8a.

Organizational support capability was only weakly positively associated with the perceived organizational value of XR ($\beta = 0.192$; $p < 0.1$); thus, hypothesis H4b was not supported using $p < 0.05$ as the cutoff. Mimetic pressure had the strongest statistically significant relationship with the perceived organizational value of XR ($\beta = 0.384$; $p < 0.001$), supporting H6. Compatibility and trialability were not statistically related to the perceived organizational value of XR. Hypotheses H7b and H8b were thus not empirically supported by the data.

Besides testing for the direct effects of each antecedent, we also carried out additional mediation analysis by testing for the indirect effects of the six TOE-based antecedents on organizational XR adoption intention via the perceived organizational value of XR and expected employee resistance to XR constructs. In addition, we tested whether the effect of expected employee resistance to XR on organizational XR

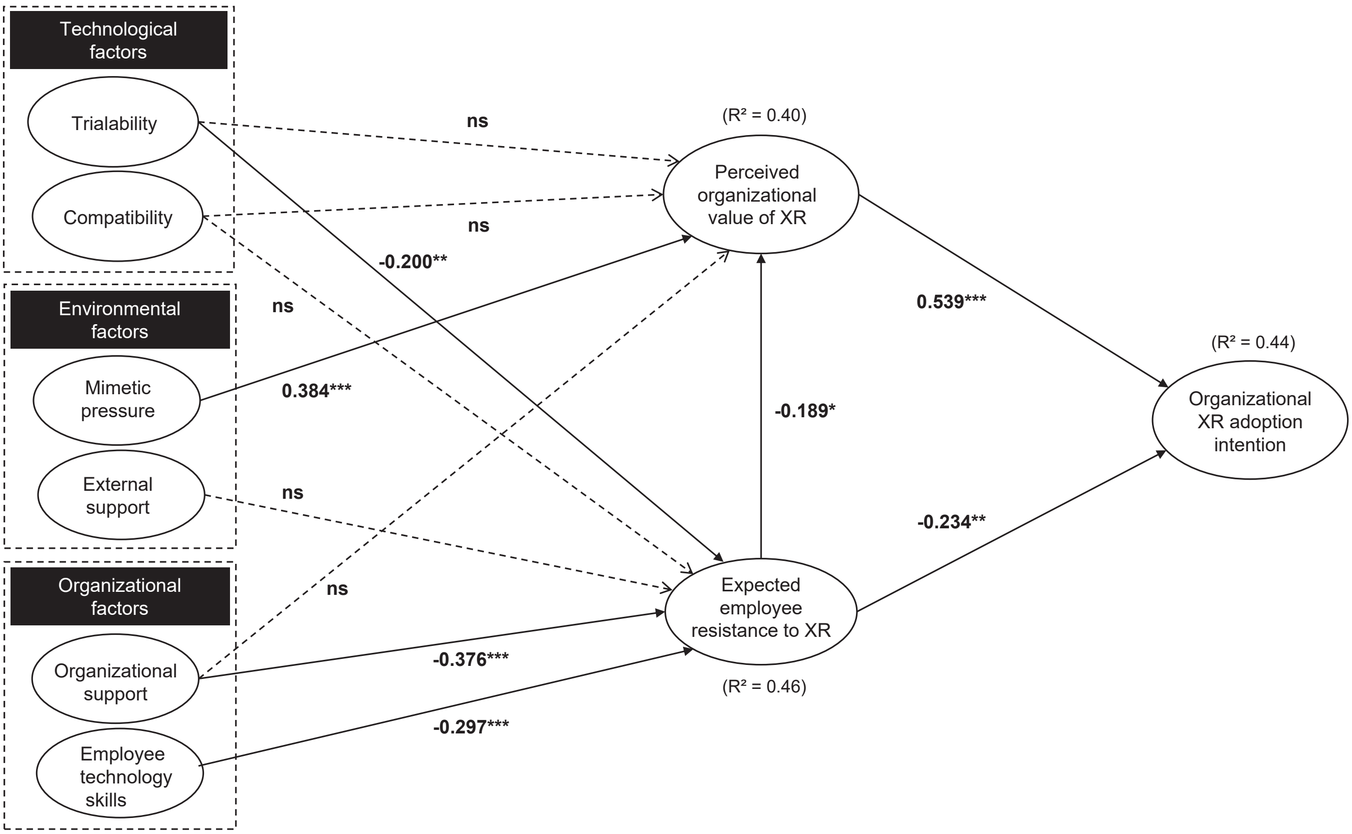

Fig. 2. Results of the path model testing (*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ns = not supported).

Table 5
Results of the hypothesis testing.

Hypothesis	Relationship	Effect	Supported?
H1a	Expected employee resistance to XR → Organizational XR adoption intention	-0.234**	Yes
H1b	Expected employee resistance to XR → Perceived organizational value of XR	-0.189*	Yes
H2	Perceived organizational value of XR → Organizational XR adoption intention	0.539***	Yes
H3	Employee technology use skills → Expected employee resistance to XR	-0.297***	Yes
H4a	Organizational support → Expected employee resistance to XR	-0.376***	Yes
H4b	Organizational support → Perceived organizational value of XR	0.192ns	No
H5	External support → Expected employee resistance to XR	0.040ns	No
H6	Mimetic pressure → Perceived organizational value of XR	0.384***	Yes
H7a	Compatibility → Expected employee resistance to XR	0.018ns	No
H7b	Compatibility → Perceived organizational value of XR	0.029ns	No
H8a	Trialability → Expected employee resistance to XR	-0.200**	Yes
H8b	Trialability → Perceived organizational value of XR	0.111ns	No

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ns = not supported ($p > 0.05$)

Table 6
Mediation results for the statistically significant paths.

Mediation path	Effect
Mimetic pressure → Perceived organizational value of XR → Organizational XR adoption intention	0.206***
Organizational support → Expected employee resistance to XR → Organizational XR adoption intention	0.088**
Employee technology use skills → Expected employee resistance to XR → Organizational XR adoption intention	0.069*
Trialability → Expected employee resistance to XR → Organizational XR adoption intention	0.047*

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

adoption intention was mediated via the perceived organizational value of XR. This analysis was carried out using the latent mediation estimand and the Indirect Effects plugin created by Gaskin et al. (2020). The statistically significant paths are presented in Table 6. Mimetic pressure's effect on organizational XR adoption intention was strongly mediated via the perceived organizational value of XR ($\beta = 0.206$; $p < 0.001$). Organizational support ($\beta = 0.088$; $p < 0.01$), employee technology use skills ($\beta = 0.069$; $p < 0.05$), and trialability ($\beta = 0.047$; $p < 0.05$) had a positive mediated effect on organizational XR adoption intention via expected employee resistance to XR. Other indirect effects were statistically insignificant ($p > 0.05$).

Finally, we controlled for organization size and organization scope in the model for all dependent variables. Although organization size has been found to be a significant antecedent of adoption intention in prior literature (Jeyaraj et al., 2006), it only had a marginally significant ($\beta = 0.128$; $p < 0.1$) positive relationship with expected employee resistance to XR. A potential explanation for this is that in larger organizations, managers can likely think of someone who might be reluctant to use XR in their work, whereas in smaller companies, managers might feel more confident in persuading their employees to use XR. None of the other relationships between the controls and dependent variables were statistically significant.

5. Study 2: qualitative contextualization of the relationships between the proximate adoption antecedents

With the validation of the importance of the expected employee resistance construct, the question of context rises to the fore. In the next section, specific conditions affecting the relationships between the proximate antecedents of organizational XR adoption intention will be explored.

5.1. Qualitative data collection

The qualitative inquiry consisted of 58 semi-structured interviews. A purposeful sampling approach was used to identify relevant informants whose companies were either considering or already using XR in their companies (Patton, 2002). The interviews were carried out in the interviewees' native languages to allow the interviewees to contemplate on their XR experiences more naturally. The interviews lasted between 45 and 75 min, and they were recorded for later transcription with the permission of the interviewees. Summaries and key quotations from these interviews were translated into English. Out of the 58 interviews, 16 were held with representatives from large companies and 42 with SME representatives. The interviews targeted senior management (16), middle management (31), lower management (4), and experts (7).

The first batch of 45 explorative interviews was conducted in nine European countries between April 2020 and October 2020. The interviews were carried out in the context of the same research project as the survey data collection of the previous quantitative study. This batch comprised five interviews each from Austria, Belgium, Cyprus, Estonia, Finland, the Netherlands, and Spain, six from Italy, and four from Germany. These interviews used an interview protocol developed by the study's authors, which was then distributed to the same research partners as described in Study 1. The interview protocol included questions about relevant technological, organizational, and environmental factors affecting XR adoption that were identified based on a review of the literature (see Appendix A).

These explorative interviews were supplemented by a second batch of 13 in-depth semi-structured interviews with four managers from three Finnish companies (eight, three, and two interviews, respectively) with extensive XR technology and implementation experience. These interviews, carried out between October 2021 and December 2022, used an interview protocol that was iterated and refined for each interview based on insights from the earlier interviews. The interview protocols were formulated around themes that were identified during a preliminary analysis of the first batch of interviews. As such, they particularly explored the themes of value and potential employee resistance and how these factors dynamically affected XR adoption in their companies. Therefore, the data collection and analysis proceeded concurrently (Gioia et al., 2013; Suddaby, 2006).

5.2. Qualitative analysis using a variation of the Gioia method

A variation of the Gioia method was applied in structuring the qualitative analysis (Gioia et al., 2013). The Gioia method uses templates in the form of data structures and data tables to structure and present the findings to provide more transparency on the analysis process, thus enhancing the trustworthiness of the findings (Cornelissen, 2017; Gioia et al., 2013). The aim of the analysis was to elaborate on the validated theoretical model (Fig. 2) and provide a more detailed and nuanced explanation of the relationships and dynamics between the three dependent variables (expected employee resistance to XR, perceived organizational value of XR, and organizational XR adoption intention; see Fig. 2). Thus, the examined dependent variables and their proposed relationships were used as categories of interest in guiding the analysis. The following analysis proceeded more inductively and did not make use of additional theoretical lenses. Thus, the process and tools provided by the Gioia method were not used rigidly, but adapted to fit the needs of the analysis (Cornelissen, 2017; Pratt et al., 2020).

The analysis proceeded by (1) identifying and grouping relevant quotes relating to the examined variables and their relationships, (2) deriving descriptive informant-driven first-level concepts based on these quotes, and (3) developing more theoretical second-order themes (i.e., adoption manifestations and conditions affecting the relationships between the variables) from these initial descriptive concepts. The outcome of this analysis is presented in the form of a data structure (Fig. 3). The findings are also finally integrated with the earlier quantitative results (Fig. 4). Further evidence and quotes from the interviews justifying the development of the themes can be found in the data tables (see Appendix D).

After an initial round of coding, an iterative step was taken in which the codes were re-evaluated. The second author also reviewed the codes at this point to confirm their face validity. The statistical significances and magnitudinal relationships revealed by Study 1 were also included in the final data structure to help contextualize the importance of the identified conditions. The contents of the data structure were then further clarified in the following sections, where the conditions and how they affect the relationships between the variables were explained with supporting quotations from the interviews.

Another aim of this additional analysis was to assist in evaluating the transferability and boundary conditions of the quantitative results. For example, one of the identified conditions affecting the relationship between expected employee resistance to XR and perceived organizational value of XR—industry innovativeness context—provides further details on the contingencies affecting this relationship. Thus, replicating Study 1 in a laggard industry context may point to an even stronger relationship between these variables. Moreover, the identified conditions may help researchers modify the constructs, rephrase the items, and develop entirely new constructs in future studies.

5.3. Findings

In this section, an overview of the qualitative findings is first presented in the form of a data structure (Fig. 3). This figure details the identified adoption intention manifestations and the conditions affecting the relationships between the key dependent variables of the validated SEM model (Fig. 2). Supportive quotations for the identified themes for the conditions and manifestations can be found in the data tables in Appendix D. In total, two key manifestations of adoption intention were identified. Moreover, 12 critical conditions affecting the three proposed variable relationships were revealed by the analysis. These identified manifestations and conditions are explained in more detail in the following subsections.

5.3.1. Organizational XR adoption intention manifestations

Two key manifestations of the companies' XR adoption intention were identified. First, the companies were interested in using XR to enhance their remote assistance and support functions, mainly with AR headsets and using their existing smartphones and tablets. The primary drivers for adopting such solutions were to realize cost savings through reduced travel and to enhance service quality by minimizing downtime for clients. This sentiment was evident in a Spanish general manager's thoughts: *"Imagine the reduction in costs and time if our technicians could assist our clients without moving to remote places!"* In addition to reducing travel, it was also noted that remote AR support could at the very least help in more accurately diagnosing problems, thus enabling the expert to prepare for the physical visit more efficiently, as mentioned by a senior key account manager from Germany:

> "We currently use remote desktop applications to support our clients, and this could be complemented with AR, particularly in the initial analysis of minor or major malfunctions and estimating the required repair effort. This could lead to savings in remote maintenance in the long term."

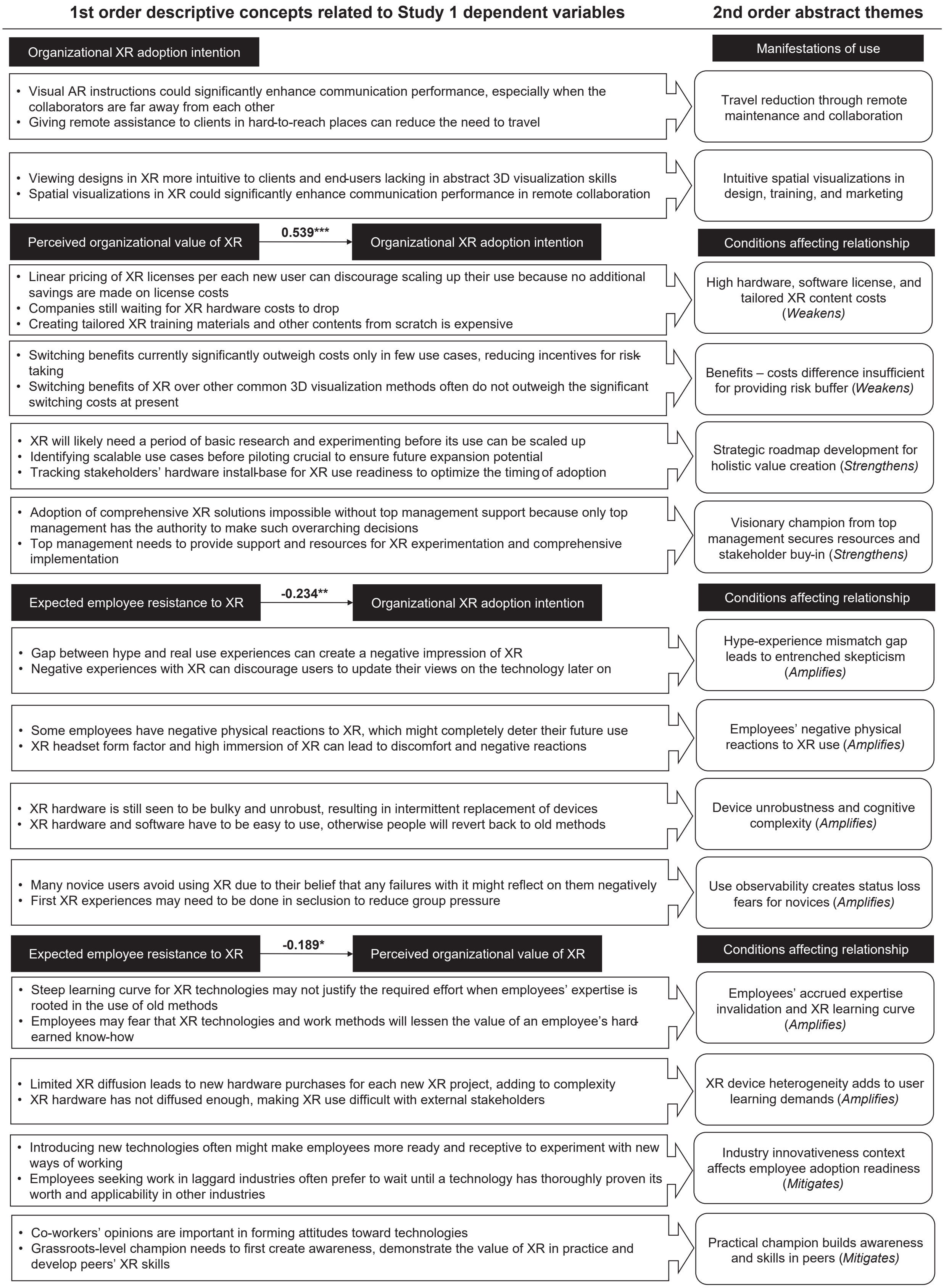

Fig. 3. Data structure of first-order concepts (left) and second-order themes (right).

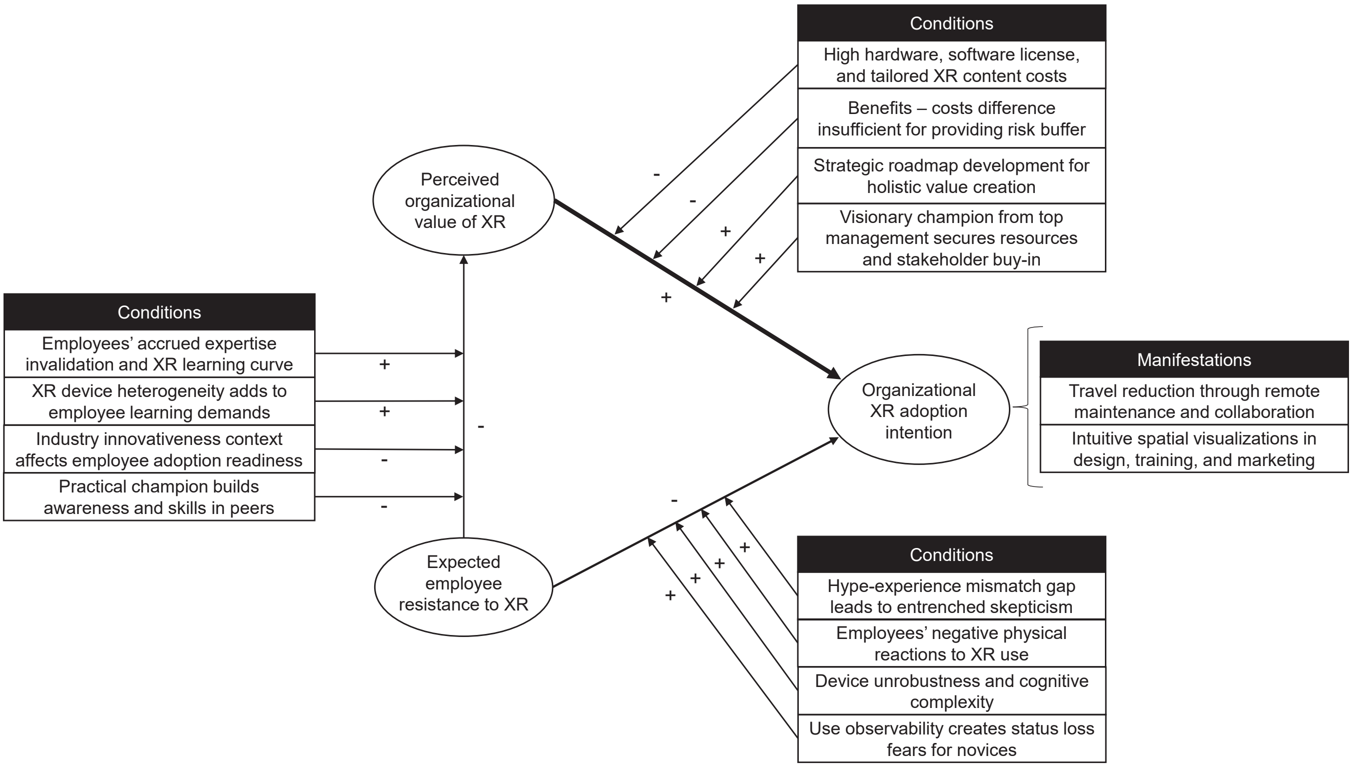

Fig. 4. Integrated model based on the quantitative results and qualitative findings.

The second use case manifestation was in making it easier for employees, stakeholders, and especially clients to better understand 3D and other digital content by leveraging the more intuitive spatial visualizations offered by XR technologies. These use cases could be implemented using either AR or VR technologies, as explained by a training manager from Germany:

> "I am aware that VR is used in other functions within the organization, certainly in the design teams in a collaboration capacity along with Siemens NX and the marketing department also makes use of AR at fairs to display digital information about our products."

However, to further leverage these value creation opportunities, many interviewees noted that efficient digital asset-to-XR pipelines should be developed. Many noted that these would have to be as automated as possible and minimize the need to manually tailor the digital content. As digital assets were reused in different use cases and by additional stakeholders, value creation possibilities were seen to increase. A manager from Finland remarked on these opportunities: *"… basically you create new value by packaging the [digital] information [with XR] in such a way that new stakeholders are able to interact with it."*

5.3.2. Conditions that affect the relationships between the perceived organizational value of XR and organizational XR adoption intention

Two conditions that weaken the positive relationship between the perceived organizational value of XR and XR adoption intention and two conditions that strengthen this relationship were identified. First, the current high costs associated with XR hardware, software licenses, and manual content customization were broadly identified as significant issues that lower the value of XR, as exemplified by a Finnish manager's comment: *"You could probably do a lot of super cool things with these, but hardware-wise, there's still the issue that construction sites are extremely unclean places. It's really risky to take sensitive hardware worth ten thousand euros into a construction site."* However, this problem was seen to be highly use-case dependent, as some companies were primarily interested in applying XR with their existing smartphones and tablets.

Second, because of the inherent risks and uncertainty involved in adopting cutting-edge technologies, many interviewees clearly weighed the switching costs associated with XR adoption more heavily than the potential switching benefits. The dilemma about the possible return on investment (ROI) was highlighted by a senior key account manager from Germany: *"There is also the question of cost, the impression is that this technology is very expensive to purchase and very expensive to maintain and operate. The return on investment is not yet clear nor persuasive."* Thus, the switching benefits related to implementing a specific use case would need to surpass the potential costs by a significant margin to provide a sufficient risk buffer for achieving profitability in the face of unforeseen challenges and realization of risks. Relatedly, companies were also concerned with the possible short-term negative financial consequences and disruptions to business processes resulting from the adoption of a transformative novel technology, such as XR. A Finnish manager noted that: *"Needing to achieve better results in the next quarter and prioritizing the short-term benefits are ever present. And the low-hanging fruits that come with a new technology? Well, even those are usually a bit higher up on the branches."* This further highlighted the challenge in the switching benefits–switching costs calculation, as the adoption-related costs were concentrated at the beginning, whereas the possible benefits emerged later.

Accordingly, it became clear that companies should not proceed with XR adoption without a clear long-term plan. Thus, based on the third identified theme, companies should first identify the most scalable use cases for their specific context through research and small-scale piloting. Following this, a long-term XR adoption roadmap should be developed to make XR's value creation opportunities evident for all relevant stakeholders. However, pursuing such developments requires both initiative and risk-taking from the company, as clear examples of how to effectively apply XR are still scant in many industries. This problem was noted by one manager from Finland who remarked:

> "Small-scale pilots are being done in many places, but you still can't find anything that's really public and done on a large scale in such a way that it has been scaled up significantly. But I'll claim that in 3–5

years some best practice examples will start to emerge to the surface."

In addition, another manager from Finland emphasized the importance of monitoring the diffusion level of their customers' XR-ready hardware install base, as this information is crucial for determining the optimal timing for implementing various XR solutions in their roadmap:

"But what we see is that when you look at the hardware install base [of our clients] is that practically only the newest iPhones have some kind of a lidar [sensor] for it [AR], which is a requirement. And those are a really small portion of mobile devices when you look at our [stakeholders'] hardware install base. What this means in practice is that if we want to get the full potential out of this, our clients have to update their mobile hardware to newer models. We've been following this very closely for the past few years to find out when we should start doing something with this. The next steps are already clear to us, but it's currently very difficult to justify the investments, because the level of customer adoption would still be very low."

Finally, as the fourth theme, many interviewees emphasized the need for a 'visionary champion' in top management. This individual would be responsible for identifying XR's role in the company's strategy and securing the necessary resources, as well as ensuring stakeholder cooperation and commitment for successful large-scale adoption. One Finnish manager noted the importance of this type of support from the top management:

"You have this conversation [about using XR] each time with a single person, who can of course only solve a single problem and not five. You'd have to win each different person [and department] on your side [regarding XR], so they are always separate battles. It's an interesting but unfortunate reality because you'd of course get much more value out of one synergistic solution."

Therefore, even though managers and employees at the grassroots level have to display a clear interest in using XR and possess the necessary skills to use these technologies effectively, a visionary champion was also seen to be crucial in developing a more comprehensive approach to XR value creation and implementation in the company.

5.3.3. Conditions affecting the relationship between expected employee resistance to XR and organizational XR adoption intention

Four conditions that amplify the negative relationship between expected employee resistance to XR and XR adoption intention were identified in the analysis. When present, these conditions were seen to be extremely difficult to overcome. Thus, they primarily affected the relationship between resistance and adoption intention directly rather than the overall value calculation for the company, as they can lead the manager to estimate XR adoption to be too difficult for the company.

First, as XR technologies have undergone several development and hype waves, it was found that the mismatch between the hype around these technologies and the actual use experiences had led to deeply entrenched skepticism toward XR in many employees, which was seen to be extremely challenging to overcome. In this regard, a Finnish manager summarized the issue: *"It feels like XR is extremely prone to bad experiences. And then, when there's all this talk about its potential, the hype is very present, and then what you realistically often run into is just challenges upon challenges."* This challenge was further exacerbated by the fact that people re-evaluated their views on emerging technologies only intermittently, or rarely in the case of deeply grounded skepticism.

Second, concerns about the effect of extensive use of XR headsets on employees' health and well-being emerged as a key obstacle. Some interviewees reported that a few of their employees had experienced negative physical reactions to using XR devices, which would likely deter future company-wide XR use, as collaborative XR use would become challenging. Thus, whenever possible, multi-device compatibility for the XR solution should be ensured. Relatedly, involving employees early in the adoption project was offered as a possible solution to this challenge by a COO from Belgium while describing the company's AR project:

"This AR application was initiated by management, but the workers have been involved in the introduction of this technology from the start of the initiative. Since some of them were not so keen to wear the AR glasses, for example, due to eye problems, management worked out a tablet alternative in parallel."

Third, it was noted that the employees' and companies' form factor and capability demands for the XR headsets were very high. They desired headsets that would be lightweight yet robust enough for demanding industrial use, while also being easy to use. However, a device that fulfilled all of these demands satisfactorily was still seen to be missing for many use cases at this point. This concern was summarized by a Belgian business analyst: *"The employees were enthusiastic about the [AR] application but remarked that the device becomes very warm, and that the battery only lasts for two hours, which is not enough to use it for a whole shift."*

The fourth theme that emerged from the analysis was that the high observability of XR use might deter many people from even trying out the XR headsets in any kind of public or social setting. A possible reason for this was their lack of skills in using the device competently and the possible embarrassment that unsophisticated use of XR devices might cause, as noted by a manager from Finland: "*Very often the thing is actually just that you don't want to embarrass yourself because you don't know how the thing works.*" Thus, employees' status concerns were seen as difficult to tackle.

5.3.4. Conditions affecting the relationship between expected employee resistance to XR and the perceived organizational value of XR

Four conditions that amplify the negative relationship between expected employee resistance to XR and perceived organizational value of XR were identified. The first theme suggests that the perceived threats that new XR-enabled work methods might pose to the employees' expertise accrued over many years might engender further resistance in employees. This concern was encapsulated by a remark from a Finnish manager: *"And you might not be interested in using VR because you don't want to learn how to do something differently when you've already spent 20 years learning how to do it the current way."* This was a key concern, as achieving a similar level of expertise with XR as with the older work methods might require a lot of time and effort due to XR's steep learning curve. Still, persuading employees of the benefits of XR and demonstrating a clear path for them to develop their XR skills were seen as possible mitigation mechanisms.

Second, because of the limited diffusion of XR hardware in companies, the problem of acquiring new XR hardware for each new XR implementation was also a critical issue, as it added to the complexity employees faced in having to learn to use several different XR devices. Thus, many companies were still waiting for a true multipurpose headset, as exemplified by a comment from an Austrian software developer: *"…sooner or later AR and VR will become natural tools in our daily life and work, just like smartphones have become essential and broadly used in the past years."* The emergence of such devices was seen to reduce employees' learning needs.

The third theme highlighted the importance of the industry context in driving managerial and employee attitudes toward the prospect of adopting emerging technologies and their readiness to carry out such changes. For example, an Austrian IT and HR manager noted that resistance from employees was not expected if XR technologies were implemented in the company because: *"Our employees are technicians who are used to permanently dealing with new developments; furthermore, they love 'technical gadgets' in general."* Some interviewees also speculated that different industries are likely to draw employees with different levels of adoption readiness and eagerness, as explained by a manager from Finland:

> "If you look at paper and saw mills and such, well, tablets are coming there only just now. They are now an 'approved technology'. After something has been proven to be useful in every other industry, they start to think that perhaps we should try this as well."

As the fourth theme, many interviewees noted that, in addition to a visionary champion from top management, a champion focused on the practical aspects of XR was also needed. In essence, this 'practical champion' would first need to create awareness among the employees by demonstrating how XR might be used effectively in practice and what value it would bring to employees, as noted by a Finnish manager: "*I really believe in this grassroots-level champion activity, I'd also really need to identify that kind of champion from our company so we could get someone to really push this thing forward.*" As interest in XR starts to increase, the grassroots-level champion would then help others develop their XR use skills and provide peer support if problems emerge. However, the scope and authority of this type of champion might often be more limited. Cooperation between the practical and visionary champions was thus seen as a key factor in enhancing organizational value creation and ensuring a smoother adoption process.

6. Discussion

6.1. Key results and findings

User resistance (Ali et al., 2016; Kim & Kankanhalli, 2009) and the perceived value of a technology (Gao et al., 2012; Kim & Kankanhalli, 2009) are critical factors in the adoption of new technologies, but their conjoint influence on organizational-level adoption of technologies has not been quantitatively examined in the extant literature. Our mixed-methods paper addresses this gap by proposing and validating a research model that incorporates decision makers' perceptions of expected employee resistance to XR and organizational value of XR and examines how these factors influence organizational XR adoption intention. Moreover, key adoption manifestations and conditions affecting the relationships between resistance, value, and adoption intention are examined in a qualitative study to elaborate on the validated model and provide a richer understanding of XR's organizational adoption dynamics.

6.1.1. Quantitative survey results of Study 1

The results show that expected employee resistance to XR is negatively associated with both the value perception of XR and the organization's intention to adopt XR. However, on balance, perceived organizational value still had a much stronger relationship with organizational adoption intention than expected employee resistance (0.539*** vs. −0.234**). Our results regarding the relationship between value and adoption intention are consistent with previous research (e.g., Chandra & Kumar, 2018; Gao et al., 2012), whereas the novel negative relationship between expected employee resistance and organizational adoption intention provides contradictory evidence to the findings of Masood and Egger (2019), whose study did not find user resistance to be a significant factor in XR implementation success. However, this disparity with our results may be explained by differences in how resistance was conceptualized, as Masood and Egger (2019) focused on ergonomics and mistrust toward the technology, whereas our research model emphasized broader attitudinal and behavioral aspects of resistance. Thus, our results are also broadly consistent with other findings from the XR literature, in which aversion to change (Davila Delgado et al., 2020), required cultural change (Badamasi et al., 2022), habitual use of previous systems because of inertia (Berg & Vance, 2017), and lack of user acceptance (Masood & Egger, 2020) have been ranked among the most critical barriers to XR adoption.

In addition, organizational support capability, employee technology use skills, and trialability were found to be negatively associated with expected employee resistance to XR, whereas mimetic pressure was strongly related to the perceived organizational value of XR. These results confirm previous findings by Masood and Egger (2019), who found that user skills development and involving users in the implementation from the outset contributed positively toward XR implementation success. Badamasi et al. (2022) also found a lack of skills to be an important barrier for XR adoption. The results are also consistent with Chandra and Kumar (2018), who found that a firm's technological competence (i.e., organizational capability to adapt its IT infrastructure for XR and train its employees to use XR technologies proficiently) increases organizational XR adoption intention.

The negative relationship between trialability and expected employee resistance is a novel association, which suggests that trialability is indirectly related to adoption intention via lower user resistance. As XR is an unfamiliar technology to most people, the opportunity to test these solutions before fully committing to them is likely linked to lower levels of resistance. The highly visible nature of XR use and its role in engendering resistance (as indicated by Study 2) further highlights the importance of well-facilitated user trials. Our results also point toward the important role of competitors' achieved benefits (i.e., mimetic pressure) in how organizations perceive the value of innovations and whether they plan to adopt them, which has been confirmed by earlier findings in the context of virtual worlds (e.g., Yoon & George, 2013) and by institutional theory more broadly, which suggests that the actions of competitors strongly affect managerial beliefs and organizational adoption intentions (Liang et al., 2007; Son & Benbasat, 2007).

Compatibility, trialability, and organizational support capability were not found to be associated with the perceived organizational value of XR, and neither compatibility nor external support were negatively associated with expected employee resistance to XR. The results on the non-significance of external support reinforce earlier quantitative findings (Masood & Egger, 2019), indicating that even with emerging technologies, such as XR, organizations prioritize internal capabilities (e.g., grassroots-level champions supporting skills development in peers, as suggested by Study 2) to avoid having to rely on external support. The non-significance of compatibility runs counter to much extant research, which has suggested that compatibility plays a critical role in the implementation of XR technologies (e.g., Masood & Egger, 2019; Jalo et al., 2020, 2022). One interpretation of this result is that the increasing sophistication of XR solutions, which often already include native IS-XR workflows with enterprise software (Torro et al., 2021), might decrease the importance of compatibility in the minds of managers. Moreover, managers may view compatibility as an initial prerequisite for adoption, which does not drive adoption on its own.

The non-significant relationship between trialability and perceived value adds to the inconsistent findings regarding the importance of trialability (Vagnani & Volpe, 2017). However, as trialability was negatively associated with expected resistance, this suggests that managers see it as more important in overcoming or proactively mitigating initial resistance, as well-facilitated trials can help overcome the initial complexity of XR (Jalo et al., 2020). Moreover, organizational support was not found to be associated with the perceived organizational value of XR, suggesting its role to be in the context of mitigating problems at the user level. As such, reducing resistance may be the more important initial consideration in the context of radically different and emerging technologies. Study 2 also points toward the critical role of the steep learning curve of XR, which likely places higher demands on immediate internal support capabilities to mitigate the emergence of resistance and entrenched skepticism.

6.1.2. Qualitative findings of Study 2

Two key adoption manifestations and 12 conditions that affect the relationships between the direct adoption antecedents were unveiled in Study 2. Organizations' adoption intentions manifested in two key overarching use cases: (1) reducing the need for travel through remote

XR collaboration and (2) enhancing stakeholders' understanding of digital content by making use of XR's intuitive spatial visualization capabilities. Two conditions that strengthen and two conditions that weaken the positive relationship between the perceived organizational value of XR and XR adoption intention were identified. First, a 'visionary champion' in top management was seen to be crucial in securing the required implementation resources and in negotiating required buy-ins from the internal and external stakeholders who would be involved in the adoption process. These issues were seen as crucial in implementing comprehensive multi-departmental XR solutions and in avoiding the siloing of XR solutions. The visionary champion would also have to develop a long-term XR adoption roadmap (in collaboration with more practice-focused champions) that fits the company strategy. However, in specific use cases and contexts, the benefits–costs calculus was still insufficient to provide the needed margin of safety in the face of unforeseen challenges and realization of risks. Because of the inherent uncertainties with emerging technologies, the identification of use cases with sufficient risk buffers is likely emphasized in such contexts. Likewise, the high costs of XR hardware, software licenses, and customized XR content were also more prevalent in certain use cases (e.g., design reviews with high-end XR headsets). The high costs and unclear ROI for many XR use cases (Badamasi et al., 2022; Davila Delgado et al., 2020; Yoo et al., 2023) are thus likely to lead to a segmented adoption of XR technologies as hardware and software solutions mature and become more affordable over time.

Moreover, four conditions were seen to amplify resistance from the employees to such a degree that this would possibly lead the company to abandon any plans to adopt XR technologies. These were the (1) deeply entrenched skepticism toward XR technologies resulting from a severe mismatch between the hype around XR and the employees' actual use experiences, (2) negative physical reactions resulting from the use of XR devices as this would make broader XR collaboration between the employees difficult, (3) the high cognitive demands inherent in learning to use radically different technologies, such as XR, as well as the current form factor and robustness limitations of XR devices, and (4) the negative social consequences that employees feared would result from the unsophisticated use of XR technologies, as their use was perceived to be highly observable in a social setting. As hype is often associated with emerging technologies (Dwivedi et al., 2022), expectation management and the effective facilitation of initial testing situations have an important role in creating positive first impressions for XR technologies. Managers also still perceived negative physical reactions from XR as an important limiting factor, which is also confirmed by the literature (e.g., Chang et al., 2020) and practical experiences from field tests (Capaccio, 2022). Moreover, challenging operating conditions have been noted to limit employees' eagerness to employ XR headsets (Masood & Egger, 2019). Lastly, the high social observability of XR use and the resultant lack of willingness from employees to test XR devices have not been widely reported in the literature. However, this can become a critical obstacle in initial implementation rollouts.

Finally, two conditions that amplify the negative relationship between expected employee resistance and perceived organizational value and two conditions that mitigate this relationship were identified. First, the potential of XR to invalidate the accrued expertise tied in old working methods and the associated learning investments employees would have to make to achieve a similar level of expertise with XR were potentially engendering further resistance. This can be seen as a specific expression of employees fearing they might lose something due to the changes brought about by the adoption of a new technology (Kim & Kankanhalli, 2009; Markus, 1983). These concerns were further exacerbated by the highly heterogeneous assortment of XR devices that are currently in use, which adds to the already significant complexity and high learning demands placed on employees. However, the innovativeness of the company's industry context was seen to mitigate these challenges, as employees in pioneering companies and industries are more likely to be used to dealing with life-long learning demands. Thus, pioneer and laggard companies (Rogers, 2003) are likely to face vastly different resistance challenges, as conservative industries have found it difficult to attract XR experts (Davila Delgado et al., 2020). Furthermore, the existence of a 'practical champion' at the grassroots level who would spread awareness about XR and help the employees develop their XR skills was seen to have an integral role in mitigating resistance. Thus, although the importance of adoption champions has been noted in the XR literature (Berg & Vance, 2017; Jalo et al., 2020, 2022), the identification of novel champion subcategories clarifies the dynamics between different types of change agents in organizations.

In summary, the qualitatively identified manifestations and relationship conditions integrated with the results of the SEM model are shown in Fig. 4.

6.2. Theoretical contributions

This study makes three contributions to IS research. First, although extant research has noted the critical role of user resistance when organizations adopt technologies (e.g., Kim & Kankanhalli, 2009; Markus, 1983; Rivard & Lapointe, 2012), the present study is among the first to highlight the magnitude of user resistance's effect on organizational-level adoption intentions by contrasting the effects of expected employee resistance toward adopting XR with its perceived value for the organization. Our study draws on user resistance (Kim & Kankanhalli, 2009) and value-risk adoption (Gao et al., 2012) models to explain how managers evaluate the adoption of new technologies in their organizations. In combining these theories, we conceptualized expected employee resistance as a specific adoption risk (Gao et al., 2012; Kim & Kankanhalli, 2009). This contribution is important because managers do not evaluate the potential of a technology in an ideal situation (i.e., with unlimited resources and completely receptive employees) but in the context of their employees and how they are likely to respond to its introduction. These results have broader implications as well, since resistance is often not limited to specific IT solutions but can also be seen as a general opposition to changing the status quo (Bhattacherjee & Hikmet, 2007; Kim & Kankanhalli, 2009).

Second, in addition to the direct, or proximate, antecedents of organizational adoption intention, the TOE framework was used to examine how compatibility, trialability, mimetic pressure, external support, organizational support capability, and employee technology use skills are related to expected employee resistance to XR and the perceived organizational value of XR. Instead of tracing the effects of these antecedents directly on adoption intention (e.g., Chandra & Kumar, 2018; Masood & Egger, 2019), we demonstrate how they relate to the two primary antecedents that managers evaluate when their organizations consider adopting new technologies. This contribution is important, because including these TOE-based antecedents in the model helps to create a more comprehensive and nuanced picture of the underlying mechanisms influencing XR adoption intention. Moreover, the validated model thus suggests that these distal antecedents do not drive adoption directly, but via their effects on more proximate adoption antecedents. In this regard, our study suggests that managers believe that internal support capabilities, employee use skills, and the ability to test out XR technologies before adoption to be negatively associated with expected employee resistance to XR, whereas organizations largely evaluate the value of XR vis-à-vis how their competitors have accrued benefits from its adoption.

Third, the qualitative contextualization of the model through the identification of key conditions affecting the relationships between its key dependent variables helps clarify under what circumstances and contexts the relationships of the model are likely to be weaker or stronger. Thus, these findings can also provide guidance and a roadmap for future theory and construct development and testing (Gioia et al., 2013). Although many of these conditions have been shown to be crucial at the individual level, for instance, how negative physical reactions to XR can deter individual use (Chang et al., 2020), our findings indicate that organizational decision makers also take these issues into account at the aggregate organizational level. Furthermore, the characteristics of these findings point toward the role of the proximate adoption antecedents as being sufficient antecedents for adoption. For instance, if employees report experiencing negative physical symptoms from using XR devices, this condition may amplify the negative relationship between resistance and adoption intention to such a degree that the organization will refrain from adopting XR solutions, even if the organization has the capabilities to effectively support its adoption. Conversely, the distal antecedents of the theoretical model could best be described as necessary but insufficient adoption antecedents.

6.3. Implications for practice

The results of our study have important implications for organizational decision-makers and XR vendors. First, as employee resistance was shown to have a significant negative relationship with value perceptions and organizational XR adoption intention, managers need to devote time and resources to identifying the sources of resistance and formulating specific mitigation strategies for different resistant groups. For example, some users may want to give their input into designing the XR solution, whereas others may want more information about what changes XR will bring to their daily work routines and how much effort mastering the new technologies will require from them. Taking a proactive approach with these challenges can also help create broader support for XR implementations in the organization if other decision makers know that such potential issues are already being mitigated.

In addition, understanding that user resistance can stem from different sources can help develop appropriate managerial interventions. For instance, perceived high learning demands or entrenched negative beliefs about the technology from previous experiences may have an important role in amplifying employee resistance. However, managers should be mindful in designing resistance mitigation interventions. Ideally, to proactively address resistance, managers should identify specific XR use cases where its value aligns with that of the organization and its employees, as this will likely help preempt the emergence of resistance. As a result, employees will likely also be more eager to utilize XR technologies. This can increase the value of adopting a technology for the organization as less effort and resources will be required to mitigate resistance.

In light of the results, properly facilitated pre-adoption user trials are recommended, as they can enable managers to obtain a more realistic view about employees' responses to XR and provide employees with initial experiences with XR or enable them to update their views about the technology. Such testing situations should also enable employees to first familiarize themselves with XR technologies in a private setting to increase their confidence and readiness to use XR in a social context. As users' physiological responses to XR use are critical in such situations, appropriate XR equipment where the prevalence of such issues (e.g., nausea) have been minimized should be chosen to enable as many users as possible to utilize XR devices. In addition, the simplicity and robustness of the XR devices should be taken into consideration as this is likely to improve employees' perceptions of the technology's practical applicability. Relatedly, managers should also seek to minimize the number of different XR devices by identifying suitable XR equipment that can be utilized in multiple use cases. This is crucial, as it can reduce the learning demands placed on employees. The industry's innovativeness context and demographics should also be taken into account when planning initial trials, as more innovative adopter groups are likely to have prior familiarity with XR from other use contexts.

The results also highlight the importance of creating internal capabilities to support XR adoption and use, rather than relying on external support. The appropriate support structures and capabilities likely differ between companies. However, ensuring that at least some employees possess expert knowledge and skills with XR can lower the threshold for employees to seek assistance from their peer group on how to use XR more effectively. Thus, identifying influential employees who could act as grassroots-level champions for XR can help ensure a smoother adoption process.

These practical champions should also aim to spread awareness about XR before adoption. Different approaches may be effective here. However, since much of XR usage is still focused on entertainment and gaming, a playful approach may be beneficial for creating positive initial impressions of XR before introducing more professionally-oriented XR solutions. Due to the hype surrounding XR technologies, champions also need to manage expectations by giving accurate information to employees about XR capabilities and features. In addition, increasing the XR skill level of employees is crucial, as this was found to be negatively related to expected employee resistance. Having XR devices available for employees to experiment with before actual rollouts can be useful, as it provides employees with opportunities to improve their skills.

Moreover, as compatibility was not found to be negatively associated with expected resistance, managers should avoid overemphasizing it as an internal selling point for XR. Nevertheless, managers should still ensure that the new XR solutions integrate seamlessly with organizational IS to ensure the rapidness of new XR-enabled workflows. This can reduce the complexity of XR for end users and lessen the effort required to learn how to use the XR solutions as part of the organization's business processes.

To lower the barriers to XR adoption for their clients, XR vendors should focus on creating effective self-service tutorials for their XR solutions (i.e., indirect external support) rather than merely offering expert consulting and support services (i.e., active external support). XR vendors should also allocate time to ensure the transfer of essential initial skills to end users when delivering solutions to clients. This practice can contribute to forming more positive initial impressions of XR for the end users and potentially prevent the emergence of resistance. These practices can help XR vendors avoid potential returns or cancellations of XR implementation projects, while also enabling their clients to immediately start gleaning value from their XR solutions.

Since mimetic pressure was found to be strongly associated with XR's value perception, change agents within organizations need to highlight the successful XR implementations of their competitors. This approach can enhance the perceived value of XR for internal organizational decision-makers, thereby increasing support for adoption and aiding in securing the needed resources and stakeholder cooperation. This is relevant for companies ranging from innovators to laggards, as companies often compare their activities to their peers or those who are considered to be more innovative.

However, managers should not be too swayed by their competitors' actions, as adopting identical XR solutions may not lead to a proper fit with the company's business processes. In order to minimize the risk of cancelled implementations, managers need to identify key initial use cases that offer the most value for the organization. Such solutions also possess the largest risk buffers in case of implementation challenges, which can aid in sustaining support for the XR implementation during the resolution of issues. Focusing on use cases that leverage the inherent strengths of XR in remote collaboration and spatial examination of digital information can be a useful heuristic for managers in identifying relevant use cases.

Lastly, to better establish the long-term overall value of XR for the organization, managers should develop an XR adoption roadmap with a clear value-creation logic to support its widespread future adoption. This should be done in cooperation between the more practice-focused champions and visionary top-management champions to leverage their expertise and influence. For instance, it is likely that the grassroots-level champions are better positioned to identify new XR features and potential use cases, while the top-management champions can better evaluate whether these novel capabilities could be utilized to re-engineer business processes or even change the strategic direction of the organization. Moreover, due to the emerging nature of XR technologies, newer iterations of XR solutions may offer significantly improved performance, lower costs, and wholly new features and use cases. As such, the roadmap should be reviewed and revised at regular intervals to keep the adoption roadmap up-to-date.

6.4. Limitations and future research topics

Our study has certain limitations. First, our study used a cross-sectional survey design. Although cross-sectional studies can be useful in estimating the relationships between different variables, they cannot be used to establish direct causality (Maier et al., 2023). We aimed to address this limitation by carrying out a qualitative study to provide a richer understanding of the relationships between the dependent variables. Future studies should adopt multi-wave longitudinal research designs to determine what causal effects expected resistance, perceived value, and adoption intention ultimately have on actual organizational adoption and use of XR (Jeyaraj et al., 2023; Maier et al., 2023). Moreover, other quantitative techniques, such as fuzzy-set Qualitative Comparative Analysis (fsQCA), could be utilized to determine whether more complex relationships exist between the pertinent variables besides their direct relationships (Mattke et al., 2022; Pappas & Woodside, 2021). The results of our study can act as a useful reference to inform the design of such studies.

Second, the data were collected from European companies. Future studies should examine whether the results of the present study hold true in other organizational and national contexts. For instance, expected employee resistance may play a different role in organizational adoption considerations in other cultural contexts (Bagchi et al., 2004). Moreover, as the sample was collected from industry, the results might not be fully generalizable to other organizational contexts (e.g., public institutions) due to their differing managerial incentive structures (Heath et al., 2022).

Third, AR and VR are perceived as radical or discontinuous rather than incremental technologies (Damanpour, 1991; Dewar & Dutton, 1986; Rauschnabel, 2021). Thus, the results of our study are likely to be more transferable to other transformative technology contexts, such as artificial intelligence and collaborative robots, which are likely to generate stronger resistance in employees compared to more established technologies. The roles of certain antecedents included in the research model are also likely to be more significant when examining emerging technologies. For instance, mimetic pressure's effect on perceived value is likely to be more significant in the context of visible, transformative technologies, such as XR, as managers can more easily identify their use among competitors compared to incremental technologies (Vagnani & Volpe, 2017).

Fourth, this study focused on decision makers' perceptions of expected employee resistance. However, managers cannot naturally know the true level of user resistance or how it will manifest beforehand. Nevertheless, their perceptions are important as they influence organizational adoption intentions. Future studies could seek to confirm the accuracy of these managerial perceptions by contrasting managerial views with individual-level employee samples. Moreover, we do not claim that every important antecedent affecting managerial expectations of user resistance and perceived value was included in our study. For example, some factors that have received consistent empirical support, such as top management support (Dong et al., 2009; Jeyaraj et al., 2006), were not included in the survey.

Fifth, future studies could examine how employee characteristics, such as employees' negotiating power (Markus, 1983; van Offenbeek et al., 2013), or additional XR-specific issues, such as fashionability (Herz & Rauschnabel, 2019) or security and privacy (Dwivedi et al., 2022, 2023), affect the relationship between expected resistance and organizational adoption intention or perceived value. Lastly, to respond to recent calls to examine customer attitudes toward XR technologies (Dwivedi et al., 2022, 2023; Hennig-Thurau et al., 2023; Yoo et al., 2023), the examination of resistance could be expanded from the internal employee context to external stakeholder groups in order to determine whether resistance from various groups influences organizational adoption in distinct ways.

7. Conclusion

Organizational adoption of technologies is a multi-faceted phenomenon. However, as organizations ultimately consist of people, decision makers must consider how the organization's employees will respond to the introduction of new technologies. In this mixed-methods study, we quantitatively demonstrate how expected employee resistance to XR is negatively related to both organizational XR adoption intention and perceived organizational value. Moreover, our results suggest that organizations with the capability to support their employees in changing to the new ways of working with XR, as well as those where the employees are already proficient with XR or can test out the technologies before their implementation, expected less resistance from their employees toward the adoption of XR. Nevertheless, the primary importance of perceived organizational value indicates that organizations will still likely go ahead with adopting XR if its value is perceived to be higher for the organization than the costs and difficulties associated with mitigating employee resistance. In this regard, our second qualitative study further unveiled 12 key conditions that may either amplify or mitigate these relationships. While our study focused on XR technologies, the findings are also likely relevant in the context of other emerging transformative technologies. Our validated organizational-level adoption model will be useful for researchers as a basis for further theory development and as guidance for practitioners responsible for planning and carrying out the adoption of XR technologies in their organization.

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CRediT authorship contribution statement

Henri Jalo: Project administration; Supervision; Conceptualization; Methodology; Investigation; Data curation; Formal analysis; Visualization; Writing – original draft; Writing – review & editing. **Henri Pirkkalainen:** Funding acquisition; Conceptualization; Methodology; Investigation; Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Table A1
Review of organizational XR adoption literature (resistance-related findings italicized).

Study	Theoretical lens	Technology and context	Method and sample	Factors affecting organizational XR adoption (+/-)		
				Technological	Organizational	Environmental
Badamasi et al. (2022)	-	VR Construction	Survey	Costs of VR (-), development costs (-), technological immaturity (-)	Lack of user skills (-), *required cultural change (-)*	-
Berg and Vance (2017)	-	VR Industry	Interviews	Tailoring the content for different users (+), VR facility costs (-)	Internal champion (+), *habitual use of previous systems due to inertia (-)*	-
Chandra and Kumar (2018)	TOE framework	AR E-commerce	Survey	Technological competence (+), relative advantage (+)	Top management support (+)	Consumer readiness (+)
Davila Delgado et al. (2020)	-	XR Construction	Workshops and a survey	Technological immaturity (-), implementation costs (-), lack of XR interoperability (-)	Lack of experts (-), unclear ROI (-), *aversion to change (-)*	Lack of external support (-), complex stakeholder networks (-)
Jalo et al. (2018)	-	AR Construction	Interviews	IS integrations and APIs (+), diffusion of enabling technologies (+)	-	Interorganizational cooperation (+)
Jalo et al. (2020)	Diffusion of innovations	VR Construction	Interviews	IS-VR compatibility (+), multi-device compatibility (+), HMD ease-of-use (+)	Lead users (+), competence with 3D models (+), collaborative initial trials (+)	-
Jalo et al. (2022)	TOE framework	XR Construction and Manufacturing	Interviews	IS compatibility and rapid workflows (+), technology install base (+), trialability access (+)	Top management support and resources (+), employee expertise (+), *user resistance mitigation (+)*	XR vendor ecosystem maturity (+), mimetic pressure (+), stakeholder readiness (+)
Masood and Egger (2019)	TOE framework	AR Industry	Interviews and a survey	System configuration (+), hardware readiness (+), compatibility (+)	Organizational fit (+), *user barrier (not significant)*	-
Masood and Egger (2020)	TOE framework	AR Industry	Field experiments	Lack of IS-AR compatibility (-), limited hardware capabilities (-), content creation difficulties (-)	*Lack of user acceptance (-)*	-

Appendix B

Cross-loadings of the items from the EFA (principal axis factoring, promax rotation).

Table B1
Item cross-loadings.

Construct / Item	1	2	3	4	5	6	7	8	9
RESI_1	**-0.777**	0.054	-0.026	0.033	0.012	0.086	-0.141	-0.042	-0.003
RESI_2	**-0.757**	0.031	-0.048	0.040	-0.112	0.043	0.148	0.005	-0.061
RESI_3	**-0.800**	-0.055	-0.029	-0.074	-0.048	-0.028	0.141	-0.023	-0.081
RESI_4*	**-0.786**	-0.043	0.104	-0.002	0.059	-0.100	-0.109	0.030	0.107
COMP_1	-0.041	**0.885**	0.020	0.020	0.061	-0.084	-0.014	-0.007	0.002
COMP_2	0.020	**0.825**	0.077	0.045	0.023	0.045	-0.061	0.046	0.007
COMP_3	0.036	**0.912**	-0.105	-0.060	-0.069	0.040	0.133	-0.024	-0.007
VALU_1	-0.046	0.027	**0.865**	-0.019	0.035	-0.045	0.047	-0.038	0.034
VALU_2	0.092	-0.098	**0.723**	0.042	-0.046	0.112	0.122	0.003	-0.100
VALU_3	-0.040	0.023	**0.874**	-0.035	-0.019	0.023	-0.009	0.014	0.002
EXSU_1	0.079	0.021	-0.005	**0.905**	-0.081	0.012	0.026	-0.032	-0.022
EXSU_2	0.009	-0.023	-0.068	**0.850**	-0.042	-0.005	0.123	-0.065	-0.001
EXSU_3	-0.110	-0.002	0.057	**0.755**	0.161	-0.031	-0.113	0.107	0.013
ETUS_1	-0.038	0.009	-0.084	-0.047	**0.925**	0.018	0.094	0.023	-0.021
ETUS_2	0.144	-0.062	-0.026	-0.047	**0.672**	-0.057	0.143	-0.012	0.074
ETUS_3	0.031	0.043	0.093	0.095	**0.879**	0.028	-0.127	-0.043	-0.033
MIME_1	-0.094	-0.078	-0.025	0.017	0.145	**0.692**	0.076	0.053	0.061
MIME_2	-0.031	-0.022	0.046	-0.010	-0.027	**0.878**	0.020	-0.022	0.029
MIME_3	0.113	0.079	0.029	-0.022	-0.071	**0.876**	-0.096	-0.007	-0.021
USE_1	0.024	0.042	0.183	-0.028	-0.003	-0.064	**0.744**	-0.018	0.034
USE_2	-0.007	0.022	-0.016	0.054	0.075	0.056	**0.825**	0.015	0.026
USE_3	-0.031	0.013	0.024	0.024	0.004	-0.013	**0.931**	0.025	0.009
TRIA_1	0.025	-0.043	-0.064	0.078	-0.125	-0.012	0.025	**0.834**	0.068
TRIA_2	-0.060	0.064	0.141	-0.012	-0.021	-0.036	-0.064	**0.754**	0.074
TRIA_3	0.045	-0.004	-0.079	-0.075	0.113	0.055	0.059	**0.810**	-0.150
ORSU_1	-0.109	0.039	-0.076	-0.002	0.087	0.097	-0.001	-0.033	**0.846**
ORSU_2	0.069	0.023	0.057	-0.024	-0.050	-0.078	0.013	0.007	**0.811**
ORSU_3	0.086	-0.060	-0.016	0.015	-0.051	0.033	0.059	0.008	**0.744**

Note: RESI, Expected employee resistance to XR; COMP, Compatibility; VALU, Perceived organizational value of XR; EXSU, External support; ETUS, Employee technology use skills; MIME, Mimetic pressure; USE, Organizational XR adoption intention; TRIA, Trialability; ORSU, Organizational support capability.

*RESI_4 item was removed during CFA due to low standardized loading.

Appendix C

Scales used in the CFA and SEM analysis.

Table C1
Constructs and items along with their standardized CFA loadings, means, and standard deviations.

Constructs and item wordings	Standardized loading	Mean	Standard deviation
Perceived organizational value of XR - (Kim & Kankanhalli, 2009) - VALU - The decision maker's overall perception of the value XR			
VALU_1: Considering the time and effort that our organization has to spend, the change to the new way of working with this technology is worthwhile.	0.865***	4.95	1.254
VALU_2: Considering the loss that our organization incurs (e.g., short-term financial loss from adopting this technology), the change to the new way of working with this technology is of good value.	0.812***	4.94	1.210
VALU_3: Considering the hassle that our organization has to experience, the change to the new way of working with this technology is beneficial to our organization.	0.853***	4.97	1.199
Expected employee resistance to XR (Kim & Kankanhalli, 2009) - RESI - The decision maker's perception of the overall level of potential resistance from employees to XR			
RESI_1: Employees in our organization will not cooperate with the change to the new way of working with this technology.	0.788***	3.05	1.410
RESI_2: Employees in our organization oppose the change to the new way of working with this technology.	0.806***	3.26	1.520
RESI_3: Employees in our organization do not agree with the change to the new way of working with this technology.	0.868***	3.18	1.363
Organizational XR adoption intention (Venkatesh et al., 2003) - USE - The decision maker's perception of the organization's intention to adopt XR			
USE_1: I predict that our organization will use this technology in the future.	0.835***	5.34	1.436
USE_2: Our organization plans to use this technology in the future.	0.925***	4.81	1.581
USE_3: Our organization intends to use this technology in the future.	0.955***	4.98	1.488
Mimetic pressure (Liang et al., 2007) - MIME - The decision maker's perception of how much the organization's competitors have benefitted from adopting XR			
MIME_1: Our main competitors have benefitted from adopting this technology.	0.739***	3.86	1.308
MIME_2: Our main competitors who have adopted this technology are favorably perceived by others in the same industry.	0.917***	4.13	1.195
MIME_3: Our main competitors who have adopted this technology are favorably perceived by their suppliers and customers.	0.820***	4.04	1.260
External support (Igbaria et al., 1997) - EXSU - The decision maker's perception of the level of available external support for XR adoption and use			
EXSU_1: A specific person (or group) external to our organization is available for assistance with hardware difficulties with this technology.	0.887***	4.40	1.526
EXSU_2: A specific person (or group) external to our organization is available for assistance with software difficulties with this technology.	0.836***	4.25	1.603
EXSU_3: External guidance is available to our organization in the selection of hardware, software, and other equipment regarding this technology.	0.792***	4.36	1.576
Organizational support (Kim & Kankanhalli, 2009) - ORSU - The decision maker's perception of the organization's internal capabilities to support XR adoption			
ORSU_1: Our organization has the ability to provide guidance to our employees on how to change to the new way of working with this technology.	0.801***	4.48	1.640
ORSU_2: Our management has the ability to provide the necessary help and resources to enable our employees to change to the new way of working with this technology.	0.850***	4.58	1.568
ORSU_3: Our employees are given the necessary support and assistance to change to the new way of working with this technology by the organization.	0.779***	4.47	1.520
Employee technology use skills (Wang et al., 2012) - ETUS - The decision maker's perception of the organization's employees' level of XR skills and knowledge			
ETUS_1: Our employees know little about the functionality of this technology. (R)	0.906***	3.57	1.800
ETUS_2: Our employees do not know when to use this technology. (R)	0.792***	3.67	1.741
ETUS_3: Our employees know little about how to use this technology. (R)	0.881***	3.52	1.839
Trialability (Karahanna et al., 1999) - TRIA - The decision maker's perception of XR's level of trialability			
TRIA_1: Before deciding on whether or not to adopt this technology, our organization would be able to use it on a trial basis (e.g., with trial versions of the technology).	0.846***	5.17	1.361
TRIA_2: Before deciding on whether or not to adopt this technology, our organization would be able to properly try it out (e.g., the possibility to test this technology before purchasing).	0.790***	5.26	1.295
TRIA_3: Our organization would be permitted to use this technology on a trial basis long enough to see what it can do (e.g., during a trial period provided by technology vendors).	0.746***	4.99	1.363
Compatibility (Susarla et al., 2003) - COMP - The decision maker's perception of how compatible XR is with the organization's existing IS and software			
COMP_1: This technology can easily access data in our existing systems (e.g., visual models from design software).	0.896***	4.20	1.589
COMP_2: Employees can easily use this technology to retrieve information from our systems (e.g., importing 3D models for visualization purposes).	0.871***	4.22	1.564
COMP_3: This technology can effortlessly retrieve data from internal systems in our organization (e.g., existing digital models can be viewed with this technology).	0.872***	4.17	1.600

Note: *** $p < 0.001$

Appendix D

Data tables of the qualitative analysis carried out in Study 2. The tables contain supportive representative quotations for each identified theme (i.e., XR adoption manifestations and conditions affecting the relationships between key dependent variables included in Study 1 for perceived organizational value of XR, expected employee resistance to XR, and organizational XR adoption intention).

Table D1
Data table for "XR adoption intention manifestations" containing themes and supportive quotations.

Second order theme	Representative quotations
Travel reduction through remote maintenance and collaboration	"The 'time to value' is really fast [in remote AR support] when you look at it from the purchase decision to actual use. We're not talking about a several months long project here, it's more like weeks. Once you make the purchase decision and get the ball rolling, you already have your initial testing done in a couple of weeks and in a month you're in full swing." (Manager #1, Finland) "As most of our products are placed in ships or offshore platforms, we are starting to use AR as supporting tool as well, but our main problems with that is not the AR technology itself but the security, stability and quality of the connection." (General manager, Spain)
Intuitive spatial visualizations in design, training, and marketing	"Although we bring our machines with us to fairs, we can't of course bring them all with us because of transport and fair space costs, so in that sense VR could be a good addition so you could have your whole fleet in line [in VR] so you could check all of them out to see which interests you the most." (Production planner, Finland) "I do have the feeling that this [VR] is something that we should be developing. Especially when it comes to how we present our projects to our clients and end-users. It brings a certain aspect into it that will certainly be interesting. It's somewhat difficult for me to immerse myself into it [the end-user experience] because I'm so deeply involved in the planning that I know it so well. But the client or user likely doesn't know the plan so well and they could then visualize what they want in their mind. It's certainly an impressive experience when you can get right inside the plan." (Architect, Finland)

Table D2
Data table for the relationship between "perceived organizational value of XR" and "XR adoption intention" containing themes and supportive quotations.

Second order theme	Representative quotations
High hardware, software license, and tailored XR content costs	"If the XR collaboration feature were to belong to an already existing license package, then it would make its use more enticing. Because if it has its own license that you must purchase, which costs that much more again, that will obviously affect the speed of adoption." (Manager #2, Finland) "Training applications using VR are too expensive for us. Since we only have 21 employees, the ROI for such tailor-made applications is too low." (Operations manager, Belgium)
Benefits – costs difference insufficient for providing risk buffer	"For some time, we also have considered to use VR for a better visualization of our plants when they are in their planning phase, mainly so that customers would get a better idea about the plant. However, we already use 3D CAD and 3D scanning software which serves the same purpose; at the end of the day, we decided that, for us, the added value of using VR/AR in this context is too low and investments on equipment, staff training, and external services are too high for them to make sense." (IT and HR manager, Austria) "When you look at switching costs versus switching benefits, the difference can't be just a few percentage points. That's why XR is considered to be valid in training and maintenance use cases because you're talking about a gain of several tens of percentage points in those use cases. At that point people start to think that there might be something to this." (Manager #1, Finland)
Strategic roadmap development for holistic value creation	"Our organization has been familiar with VR technology for many years and has invested substantial resources in researching and experimenting with this technology. It is only in the last 2–3 years that we have begun to roll-out this technology across our organization in a meaningful way." (Training manager, Germany) "Then there's also the issue of 'pilot purgatory' where you might get stuck after the small initial pilot once you realize that the pilot cannot be scaled up." (Manager #1, Finland)
Visionary champion from top management secures resources and stakeholder buy-in	"Top management knows about AR/VR/MR technologies, not so much about the technical stuff but they know possible applications for these technologies, and they understand their potential for the company. Top management encourages the employees to experiment with new technologies. To get green light, employees have to document the request and explain the importance for the company." (Advanced manufacturing engineer, Belgium) "We are global leader in our field, and in order to maintain that status we have to keep searching for new and innovative ways of doing business. Because of our reputation, our customers expect that we can offer the most up to date training experience available. Therefore, there are very few organizational boundaries within our company that cannot be quickly overcome if a new technology proves to be able to enhance our business operations. This sentiment exists in the management level and is mirrored across every department of the organization, so any proven new technology can easily be integrated into our work processes and organizational structure." (Training manager, Germany)

Table D3
Data table for the relationship between "expected employee resistance to XR" and "XR adoption intention" containing themes and supportive quotations.

Second order theme	Representative quotations
Hype-experience mismatch gap leads to entrenched skepticism	"I'd say a big portion of it is still that you might've checked out some VR rollercoaster demo five years ago and you're still stuck there in your thinking because you haven't updated your knowledge about the technology, because you might only do that once every year or two, and even then, you only spend 0.5–1 h with it to re-evaluate your view. The knowledge and awareness about the technology just renews so slowly." (Manager #1, Finland) "Then there's been comments that someone had tried something like that earlier and how with the first glasses there was some nausea, and they weren't very eager to try them out. But when they tried them out, they realized that these things have advanced quite a bit and the nausea wasn't there anymore." (Manager #2, Finland)
Employees' negative physical reactions to XR use	"There is also the issue of health and safety of our employees. Our designers use CAD for 8–10 h a day. Would it be possible for our employees to wear a headset for 8 h without experiencing dizziness, nausea, etc?" (Business operations manager, Germany) "We used VR a couple of years ago for training some employees on how to drive a forklift. The application was fine, it was quite realistic, you had pedals and a steering wheel to drive, but some workers got dizzy." (Purchasing and investment manager, Spain)
Device unrobustness and cognitive complexity	"The hardware is a bit bulky and there is also the question of cost. This technology isn't extremely expensive, but it is fairly delicate and would have to be replaced regularly at a mounting cost." (Business Operations manager, Germany)

(*continued on next page*)

Table D3 (*continued*)

Second order theme	Representative quotations
Use observability creates status loss fears for novices	"It all culminates into how easy it is to use. It somehow goes so much hand-in-hand that if you feel it's difficult and cumbersome, its use easily falls off." (Architect, Finland) "To a person to whom it is important to fully know what they are talking about, presenting your work [with XR] is an impossibility [until the required expertise has been acquired]. You just don't do it because there are fears associated with it. It's an interesting issue. How do you get to that point where the other person feels they are so knowledgeable about the technology and so sure of its benefits that when you are displaying [your work] with the aid of this technology, you also feel like you are portraying yourself positively?" (Manager #1, Finland) "What we've tried is that we only take one person to the room with us to use the glasses, so that there is no group pressure at all. There's only one or two people there to guide the user with the glasses, and then you go through how the whole thing works button by button." (Manager #2, Finland)

Table D4
Data table for conditions affecting the relationship between "expected employee resistance to XR" and "perceived value of XR" containing themes and supportive quotations.

Second order theme	Representative quotations
Employees' accrued expertise invalidation and XR learning curve	"The first time people use VR, they need some time to get used to the controls to move, turn and jump in the virtual environment. They are often overwhelmed by the experience, which makes it harder for them to focus on their task. For example, an IT colleague who is more familiar with this technology and a colleague with a warehouse supervisor background, who should know all these hazards, both tested the application. The IT colleague had a much higher safety score than the warehouse supervisor colleague who was overwhelmed by the application and didn't identify any unsafe situations! This has been one of the main lessons learned so far. The colleague with a warehouse supervisor background spent his time discovering how to teleport, move and turn around." (Business analyst, Belgium) "Here I'd say the biggest bottleneck is that if you've spent 10 years to learn how to do something on the computer, then you might see it [adopting XR] more as you throwing away your own identity and your skills, and those also contribute toward your self-esteem in a psychological sense. So, you might not be ready to say to that person that the 10 years they put into learning was actually in vain because we have a better tool now, which essentially makes everything you've learnt before useless. I think these kinds of issues create resistance. That even if the tool is better, people don't want to adopt it because they value the old way of doing things and all the hours people put into learning those skills." (Manager #1, Finland)
XR device heterogeneity adds to user learning demands	"The main problem with this is that our clients are located all over the world, sometimes in very remote places. Adopting AR technology does not happen overnight and requires some basic infrastructural elements." (Clerk, Austria) "There aren't that many of them [XR devices] around, maybe there's one or two AR glasses here at the company or with our clients without me being aware of it. There really aren't that many of them, and then the thing is that if you make a new [XR] investment, there's always the hardware investment that comes with it, and then it's usually the case that you get that one device for that one use case instead of being like, hey, we'll get [XR] glasses for everyone or 30 % of the people, so that we'd have these seven [XR] applications available." (Manager #1, Finland)
Industry innovativeness context affects employee adoption readiness	"In our company, employees are open-minded towards new technologies. Maybe that's because almost every year we test and introduce new technologies. They are used at it. It is part of our company culture." (Operations manager, Belgium) "The aerospace industry tends to be conservative, and it has been very slow to pick it up [XR], but now with the advent of augmented reality technology it is starting to become more popular, certainly in maintenance and repair but less so in mechanical design." (Business operations manager, Germany)
Practical champion builds awareness and skills in peers	"It sort of has to come from your peer group, so there would have to be one group that's using it [XR] and then others will start getting interested in it as well. And you'd then also have to have that kind of an 'everyone's friend' in there who is really social and always ready to put the glasses on first." (Manager #1, Finland) "I think they [top management] would be open to experimenting with this technology, however, the effort and interest would have to come from the departments that want to use AR in their daily work." (Clerk, Austria)

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Henri Jalo (D.Sc. Tech.) is a postdoctoral research fellow in the unit of information and knowledge management at Tampere University, Finland. His research is mainly focused on the adoption and use of augmented and virtual reality technologies in organizations. His work has appeared in *Communications of the ACM, Virtual Reality, European Conference on Information Systems (ECIS) and International Conference on Knowledge Management and Information Systems (KMIS)*.

Henri Pirkkalainen (PhD) is an associate professor of information and knowledge management at Tampere University, Finland. His research interest is in knowledge management, technostress and dark side of information systems use. He has published in journals such as *MIS Quarterly, Journal of Management Information Systems*, *Information Systems Journal, International Journal of Information Management,* and *Computers & Education.*