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Decentralized, Iterative, and Adaptive

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Adoption of AR technologies in crisis within the pharmaceutical manufacturing industry

Master Thesis

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ABSTRACT

This paper investigates the adoption of Augmented Reality (AR) technologies within the pharmaceutical manufacturing industry in response to the COVID-19 regulations. Given that the novel context introduced by the pandemic puts into question the effectiveness of traditional technology adoption models, we adopt a grounded theory approach to develop a more nuanced understanding of the influential factors and emergent dynamics. Semi-structured interviews with 22 employees of a multinational pharmaceutical and three of its manufacturing partners reveal a distinct adoption process that is decentralized, iterative, and adaptive. This process is underscored by widespread initiative among employees, technological tinkering to optimize functionality, the multi-purpose utilization of AR tools, and enhanced collaboration across organizational boundaries. The findings highlight critical shortcomings of established models, particularly their assumptions of linear progression, top-down decision-making, and the artificial separation of technology adoption from organizational process innovations. The insights contribute to refining theoretical models and establish a potential bridge to open innovation literature. Additionally, practical guidance is provided to better navigate the adoption of disruptive technologies in response to exogenous shocks.

Keywords: Augmented Reality, Pharmaceutical Manufacturing, Technology Adoption, Technology Acceptance, Open Innovation, Grounded Theory, COVID-19.

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LIST OF ABBREVIATIONS

AID - Antecedents, Influencers, and Dynamics

AR – Augmented Reality

CMO – Contract manufacturing organizations

DOI – Diffusion of Innovation model

DIA - Decentralized, Iterative, Adaptive

ERBV – Extended Resource-Based View

GMP - Good Manufacturing Practices

IT – Information Technology

MAH - Marketing Authorization Holder

MNC – Multinational Corporation

PCM - Personal Coordination Mechanism

QA - Quality Assurance

R&D - Research and Development

SSI – Semi-Structured Interview

TAM - Technology Acceptance Model

TCM - Technology-based Coordination Mechanism

TOE – Technology, Organization, Environment model

UTAUT - Unified Theory of Acceptance and Use of Technology

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1. INTRODUCTION

In 2020, governments around the globe placed restrictions on travel and physical interactions in order to contain the spread of the COVID-19 virus. Companies had to adapt quickly and find alternative solutions to tasks and processes that previously depended on in-person interactions, opening the door to the testing and implementation of emerging technological solutions (Almeida et al., 2020).

Pharmaceutical manufacturing was notably disrupted by the COVID-19 crisis, since the industry is inherently reliant on physical processes requiring human oversight that adhere to sophisticated "Good Manufacturing Practices" (GMP) (Ayati et al., 2020; European Medicines Agency, n.d.). The manufacturing and distribution of pharmaceuticals involves coordination between a Multinational Corporation (MNC) that holds the patent for a drug, and partner Contract Manufacturing Organizations (CMOs), which are responsible for the manufacturing and distribution of drugs within a defined geography. These networks are characterized by the exchange of complex technical knowledge framed by rigid contractual frameworks (Morgan et al., 2018). Before the COVID-19 pandemic, knowledge sharing processes in the industry had traditionally relied on a mix of technological and personal methods of coordination, including in-person visits. In order to ensure the continuation of operations across outsourcing networks under the COVID-19 regulations, many companies increased their digitalization, resorting to the adoption of Augmented Reality (AR) technologies (Kudyba, 2020).

The adoption of AR technologies in real-life manufacturing remains largely understudied, with most existing studies having been conducted under laboratory conditions. This is primarily due to the fact that, prior to the pandemic, AR had failed to see widespread adoption and industry applications did not extend beyond experimental prototypes (Bottani & Vignali, 2019). Additionally, not only are we dealing with the adoption of a nascent and potentially disruptive technology, but it is happening in a novel context, where companies are adopting AR as an adaptive strategy in response to a new status quo with long-lasting effects (Brem et al., 2021). There is an unmet need to understand how regulations, as an external force, influence technology adoption and uncover the mechanisms and behaviors of adaptive adoption (Tarhini et al., 2013; Dwivedi et al., 2019; Venkatesh et al., 2016). In addition to the gaps in the literature, there is a deeper problem in regard to the assumptions of existing technology adoption models. Historically, these models have assumed a linear adoption process with top-down decision making and a fixed organizational context (Clark et al., 2019; Röcker, 2010; Frambach & Schillewaert, 2002; Ifenthaler & Egloffstein, 2020). These premises render them of little applicability to our research context, where the adoption decision, implementation and processes improvement are intertwined.

Considering the outlined gaps in the literature, and the limitations in the usefulness of existing adoption models to our research context, we assumed a grounded theory approach. This methodology was chosen in order to foster the emergence of new theory inductively and to reveal new dynamics on their own terms rather than limiting them to prior theoretical biases (Corbin & Strauss, 1990; Kenealy, 2012). We conducted semi-structured interviews (N=22) with employees across a selected pharmaceutical MNC and three partner CMOs based in Europe and North America. These companies conducted trials under real-world conditions at the beginning of 2021, using AR technologies to replace on-site visits in the later stages of their knowledge transfer processes. In this study, we focus on a series of knowledge transfer projects, but also on other examples of knowledge sharing through AR technologies that our interviewees had experienced.

Our aim is to go beyond applying existing theories, instead generating new insights into the detailed dynamics of adoption. We believe that a deep dive into these complex interrelations is essential for advancing both theoretical frameworks and practical strategies for the adaptive adoption of disruptive technologies. With this objective, we proceed to explore the following critical questions:

What emergent dynamics characterize the process of Augmented Reality (AR) adoption within pharmaceutical manufacturing as a response to the COVID-19 regulations?

- How does the exogenous shock of COVID-19 affect the strategy and execution of adopting AR in pharmaceutical manufacturing?
- What key factors influence AR adoption, and how do they differ from conventional technology adoption models?
- What implications do emergent adoption dynamics have for the development of models and frameworks that both guide theoretical understanding and assist companies in adopting disruptive technologies in response to an exogenous shock?

This thesis reveals a distinct technology adoption process that is characterized by decentralized, iterative, and adaptive strategies and dynamics. Contrasting our findings with the literature on technology adoption, we find the presence of previously studied adoption factors, and uncover novel ones. Beyond listing key factors, we focus on exploring the behavioral mechanisms that underpin the adoption dynamics. Finally, we provide insights that may contribute to the creation of practical frameworks and new theoretical models, establishing a potential bridge to open innovation literature.

This paper is structured into six chapters. Chapter 2 is the conceptual framework, covering the role of knowledge sharing within pharmaceutical manufacturing, the potential of AR as a mechanism of knowledge sharing, and a literature review of technology adoption. Chapter 3 presents the results of the interviews, structure around antecedents, influencers, and dynamics. Chapter 4 follows the same structure, contrasting the findings to the literature and discussing the underlying behavioral mechanisms. This chapter concludes with a restructuring of the results around a central theme to facilitate theory building. Finally, chapter 6 concludes with the key findings and academic implications, as well as managerial recommendations, and limitations of the study.

2. CONCEPTUAL FRAMEWORK

The present research is based on grounded theory. As such, the literature presented in this section is not a rigid framework from which hypotheses would be derived to be tested through the data collected. Instead, they serve as a means to increase theoretical sensitivity, contextualizing our research within the literature (Glaser & Strauss, 1967).

2.1 Knowledge Sharing

Knowledge sharing refers to the process by which individuals or organizations exchange information and expertise to facilitate learning and problem-solving (Nonaka & Takeuchi, 1995). In the context of the pharmaceutical industry, knowledge sharing encompasses the exchange of critical insights on regulatory compliance, processes, best practices, quality standards, and technological advancements that ensure the successful development, manufacturing, and distribution of pharmaceutical products. It is a complex process of exchanging, disseminating, and transferring knowledge, both tacit and explicit, through different mechanisms, and across various organizational levels and external partnerships (Wang & Noe, 2010; Cummings & Teng, 2003).

Within organizations, knowledge sharing is strategically oriented towards bolstering operational efficiency and driving innovation (Wang & Wang, 2012). Internally, it operates as a dynamic, ongoing process, where individuals both within and across departments exchange personal expertise, thereby enhancing day-to-day operational execution and continuous improvement (Wang & Noe, 2010). Externally, knowledge sharing extends to collaborative partnerships, playing a crucial role in joint efforts and collective problem-solving (Wang & Hu, 2020). External knowledge sharing is ubiquitous in the pharmaceutical industry, which is structured as a network where no single entity possesses all the requisite expertise or resources, fostering group interactions for shared learning and innovation (Loupes & Grygiel, 2003; Wang & Noe, 2010).

Following the extended resource-based view (ERBV), MNCs' knowledge is a strategic resource, not only within the firm but also within their networks. effective sharing of knowledge between these networks leads to enhanced innovation, improved product quality, and production process efficiency (Mathrani & Edwards, 2020; Law & Ngai, 2008). It also enhances adaptability to market changes, technological advancements, and evolving regulatory landscapes, underscoring its importance to sustain competitive advantage (Powell et al., 1996; Ambrosini & Bowman, 2001).

The pharmaceutical industry is characterized by stringent regulatory oversight, intellectual property (IP) concerns, and the imperative of maintaining high product quality and safety (Morgan et al., 2018). Companies in the industry need to thread carefully in striking the right balance between openness and secrecy, in order to maximize innovation whilst minimizing information leakages to ensure competitive advantage (Castro, 2015; Mukherjee & Stern, 2009). This is particularly pivotal in collaborations between Marketing Authorization Holders (MAHs) and Contract Manufacturing Organizations (CMOs), where joint efforts are key for innovation and compliance.

Contrasting with the more fluid and spontaneous nature of internal knowledge sharing, external knowledge sharing is largely characterized by well-defined transfer projects. Given the stringent regulatory environment of the industry, coupled with intellectual property (IP) and quality considerations, these projects demand a formalized, structured approach (Velagaleti et al., 2002;

Sangshetti et al., 2017). External knowledge transfer projects in the industry are specifically designed to disseminate highly technical and scientific knowledge, with clear goals and expected outcomes (Bignami et al., 2020). Thus, they conventionally exhibit a top-down information flow, originating from the central MNC to the peripheral CMO partners, with rigid contractual directives (De Vries et al., 2014; Morgan et al., 2018).

External knowledge transfers rely on Technology Coordination Mechanisms (TCMs) for disseminating explicit knowledge, vital to adhering to stringent regulatory standards (Nonaka & Takeuchi, 1995). TCMs facilitate both asynchronous communication, such as through digital platforms, emails, and databases, enabling time-independent knowledge sharing, and synchronous communication, through phone calls and videoconferences, offering real-time, interactive exchanges. The conveyance of tacit knowledge, however, remains a challenge in these formal and codified systems, especially in knowledge transfer projects where the subtlety and context-specific nature of tacit knowledge can be lost (Saini & Kulonda, 2019; Szulanski, 2000).

Tacit knowledge is defined as a set of rules subconsciously followed by individuals, including cognitive abilities and technical know-how (Polanyi, 1962). This type of knowledge, often unarticulated and embedded in personal experiences, benefits greatly from the immediacy and direct engagement of synchronous interactions as well as from the creation of temporal proximity (Wang & Noe, 2010; Torre, 2008). Thus, Personal coordination mechanisms (PCMs), such as face-to-face meetings, mentoring, and informal networks, are pivotal for the exchange of tacit knowledge.

External knowledge transfer projects in the industry have relied on international travel towards the later stages of the projects to ensure the temporal proximity of MNC experts on-site. Yet, with the coming of the COVID-19 regulations, PCMs were no longer an option. This pushed companies to find solutions to ensure the continuity in the transmission of tacit knowledge, opening the way for technologies with modern features which might be better suited for the transmission of tacit knowledge.

2.2 Augmented Reality Technology

AR is an advanced technology that overlays digital information onto the user's real-world environment. Unlike Virtual Reality (VR) that creates a completely virtual setting, AR enhances the real world by superimposing computer-generated images, sounds, or other data onto it, thus creating a composite view. This technology integrates digital components with the physical world in real-time, using devices such as head-mounted displays, smartphones, or tablets. AR's unique capability lies in its interactive nature and the way it augments the user's perception of the real world, offering a blend of digital and physical experiences (Azuma, 1997; Milgram & Kishino, 1994).

AR emerges as a novel Technology-based Coordination Mechanism (TCM) for knowledge sharing, which has novel features that suggest the technology is more capable of transmitting tacit knowledge than previous TCMs

AR facilitates synchronous interaction, a feature previously only available in phone and video calls, which are somewhat hybrid forms of TCMs, leaning closer to Personal Coordination Mechanisms (Nonaka & Takeuchi, 1995; Wang & Noe, 2010). However, AR distinguishes itself by allowing users to remain in physical proximity to their work environment, be it a laboratory or a factory floor. This proximity enables users to showcase real-time scenarios — such as equipment states, operational dynamics, or process failures — directly to their counterparts (Bower et al., 2017). AR has the ability to create a shared context, enhancing the understanding of both parties. Unlike in the case of a discussion over a phone call or video call with a predetermined, one-sided, very limited visual field set by the user, through a head-mounted display, AR would ensure both parties actually share the same synchronized view of the scenario being discussed. This common point of view helps not only in problem-solving but enables the counterpart to have a more complete view, including elements that the prime user had not intended to show, potentially uncovering unrecognized problems (Azuma, 1997).

AR allows guiding the user's counterpart, in the real area of the users' environment, by drawing various annotations, for example, arrows or circles. Hence, this could enable a possibility for guiding the user with more accuracy and effectiveness. (Milgram & Kishino, 1994) Moreover, real-time information about the machinery or process can be overlaid on the user view, further enriching the knowledge exchange process by providing context-specific manufacturing processes (Billinghurst et al., 2001). Considering the AR devices are head-mounted and not hand-held, the interaction occurs while allowing the user to carry on with his work, providing a better sense of the real-working conditions (Azuma et al., 2001). AR provides a medium where the virtual and real worlds coexist, allowing users to interact with both simultaneously. This interaction can extend not just into the visual space, but also include other sensory modalities like auditory or haptic feedback, enriching the experience of the user in the environment (Billinghurst et al., 2001).

In brief, AR represents a potential significant leap in knowledge sharing through TCMs, by enabling synchronous interaction, a richer transmission of information including tacit knowledge, sharing of the physical context, improved field-of-vision collaboration, and hands-free operations (Klopfer & Squire, 2008). In this respect, although AR is conceptually a TCM, its novel features open up the possibility for the knowledge to be transmitted that previously could be transmitted through PCMs only. AR has the potential to generate a knowledge sharing process that is more efficient, frequent, and with increased network connectivity.

The use of augmented reality in the manufacturing sector is on the rise. However, these technologies still largely remain in the exploratory phase, especially for processes that require on-site interaction, resulting in a majority of studies being conducted under controlled laboratory conditions (Bottani & Vignali, 2019). These controlled settings do not adequately reflect the complexities and challenges of implementing AR in real-world manufacturing settings (Akçayır et al., 2016). While studies like those conducted by Müller et al. (2023) and Lehrbaum et al. (2022) delve into AR's application in manufacturing and remote maintenance, they often stop short of addressing the unique challenges and opportunities presented by industries subject to stringent regulations.

2.3 Technology Adoption

The central focus of this paper is technology adoption, a significant domain within the broader spectrum of innovation literature. Beyond the gap concerning limited real-life studies on AR adoption, another notable limitation lies in the inability of the field to have generated frameworks applicable to an adaptive and non-linear adoption. This is in part due to the significant fragmentation in the literature, generating parallel research directions that have yet to be structured into a holistic framework (Van Oorschot et al., 2018). In order to shed light on this issue, let us dive into the historical development of the field and examine the current state of research.

Roger's *Diffusion of Innovations model* (DOI), initially developed in 1962, provides a view of how innovations spread across societies, focusing on the characteristics of innovations and the roles of adopters. While DOI offers valuable insights into societal and cultural adoption patterns, it does not directly address the organizational and individual decision-making processes that underlie technology adoption in specific settings. This model primarily outlines a broad pattern of adoption without delving into the intricacies of organizational dynamics and individual user engagement with technology (Rogers, 2003).

The Technology-Organization-Environment (TOE) Framework shifts the lens to the organizational context, exploring how technological, organizational, and environmental factors influence the decision to adopt new technologies (Tornatzky & Fleischer, 1990). TOE effectively addresses the context of primary adoption, which involves the organizational decision-making phase where leadership decides to adopt a technology. This phase is characterized by evaluating the technology's alignment with organizational goals, its potential impact on operational processes, and the readiness of the organization to implement the new system (Tornatzky & Fleischer, 1990; Sahamir & Ismail, 2021). Yet, it does not fully explore the secondary adoption, which involves the acceptance and use of the newly adopted technology by the individual users within an organization. The model implies a linear progression from decision to implementation without acknowledging the complexities of secondary adoption or subsequent phases of technology integration, not accounting for the iterative feedback loops that can significantly influence the adoption process.

Other models have focused on secondary adoption, examining the determinants of individual users' acceptance and usage of technology. Early findings, like those from Bailey (1983), highlighted key determinants of technology satisfaction for an individual, including accuracy, reliability, timeliness, relevancy, and confidence in systems. These foundational factors have influenced subsequent models in the field of technology adoption.

The majority of technology adoption research has focused on secondary adoption, using as foundational theory Davis's Technology Acceptance Model (TAM) introduced originally in 1985 (Van Oorschot et al., 2018). TAM builds upon the psychological Theory of Reasoned Action (TRA) to explain technology usage. TAM proposed that perceived usefulness and ease of use are critical cognitive responses that determine an individual’s attitude and in turn their behavioral intention toward technology use. Attitude is understood as an individual’s positive or negative feelings about performing a behavior. In the context of TAM, attitude is shaped by an individual's beliefs about the outcomes of using technology, which are weighed against their evaluations of those outcomes, and it is considered a key determinant of the intention to use or accept a technology (Venkatesh et al., 2003).

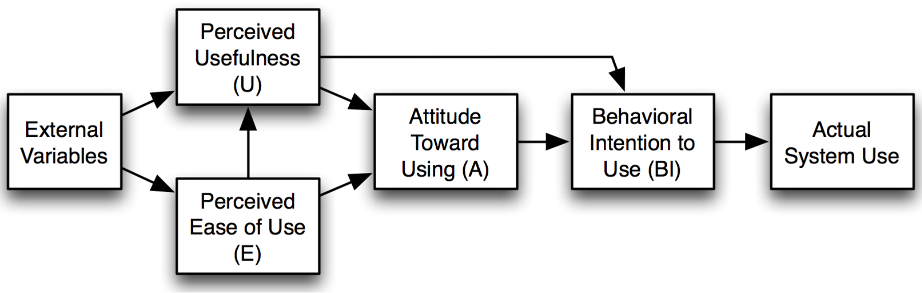

Figure 1: Technology Acceptance Model (Davis, 1985)

TAM's later expansion into the Unified Theory of Acceptance and Use of Technology (UTAUT) broadened this perspective, incorporating social influence and facilitating conditions to better understand the nuances of secondary adoption. However, these models primarily address the user acceptance following the organizational decision to adopt, not addressing the complex, bidirectional dynamics between primary and secondary adoption phases, nor the ongoing engagement with technology post-adoption (Davis, 1985; Venkatesh et al., 2003).

The TAM has become commonplace in the field, in great part thanks to its understandability and simplicity (Hsiao & Yang, 2011; King & He, 2006). Moreover, TAM has proven to be “a powerful and robust predictive model” (King & He, 2006, p. 751). Perceived usefulness has been found to be profoundly influential on behavioral intention, even capturing much of the influence of perceived ease of use (King & He, 2006). There is an evident parallel between perceived usefulness and the influential success factors found previously by Bailey (1983): accuracy, reliability, timeliness, relevancy, and confidence in the systems. Although these factors were specific for the usage of computer systems, the simplification of TAM allows for a wider applicability, and subsequent greater specification depending on the context and technology.

The TAM has since been tested and developed by many researchers leading to the incorporation of new factors (Legris et al, 2003). Figure 2 presents a condensation of TAM modifications presented in a odoa-analysis conducted by King and He (2006). The categories within the framework are broad enough to allow for insights to emerge, rather than having rigid factors from which to derive hypotheses, and specific enough for the insights to be organized. This will aid in comparing our findings to previous studies on technology acceptance and identify key areas of inquiry, informing the investigation of underlying dynamics, relationships, and feedback mechanisms that drive technology usage and acceptance.

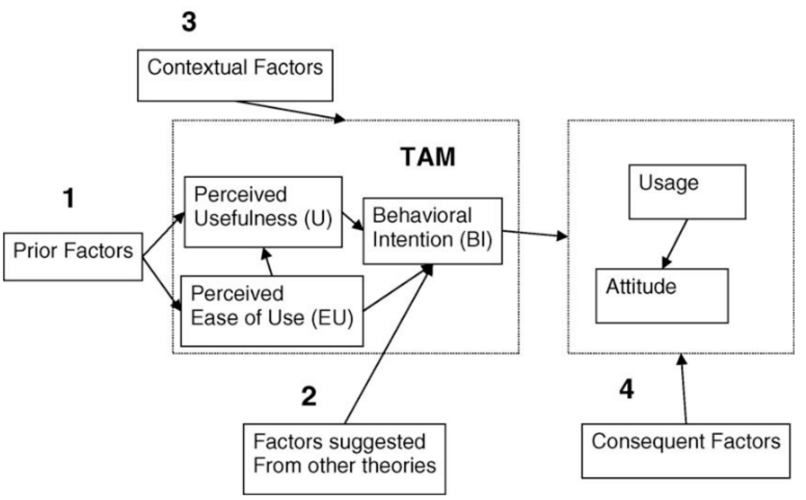

Figure 2: TAM and four categories of modifications (King & He, 2006)

1) **Prior factors**: these refer to external precursors such as prior experience with the technology, which we anticipate will play an important role in the research context of this study since it has been found to be influential when dealing with nascent technologies (Oh et al., 2003). Also, situational involvement, that is the participation in activities regarding the development or implementation of the technology, which has been found to positively affect the adoption process (Jackson et al., 1997; Leso & Cortimiglia, 2022).

2) **Factors suggested from other theories**: such as the social influence and facilitating conditions present in the UTAUT (Venkatesh et al., 2003). Risk, which is prevalent in the industry arising from diverse sources, from potential exposure to hazardous substances and contamination threats, to accidentally sharing classified intellectual property and ensuring compliance with data and quality standards (Pavlou, 2003). Trust, which could play a significant role since the technology is being tested on the field and the interactions are taking place between employees of different organizations, who might or might not have pre-existing relationships (Gefen et al., 2003; Gefen, 2004). And task-technology fit constructs, specifically pertinent considering the differing features and components of the technology system, considering the different devices and software being tested, as well as the potential complexity of utilizing them within a strict manufacturing physical and legislative environment (Dishaw & Strong, 1999).

3) **Contextual Factors**: these are factors that could have moderator effects. For instance, gender, age - which area outside of our scope, considering our methodological approach – and voluntariness of use present in the UTAUT (Venkatesh et al., 2003). The last one being of paramount interest to the study, since our research question is aimed at understanding how the technology acceptance process takes place when triggered by an exogenous event, i.e., where adoption is not completely at the will of the employee, but also not fully mandated. Technology characteristics have also been found to act as a moderator (Plouffe et al., 2001).

4) **Consequent Factors**: looking beyond the acceptance of the technology at how attitude is affected (Davis et al., 1989), as well as distinguishing between perceptual usage (Horton et al., 2001; Moon & Kim, 2001) and actual usage (Davis & Venkatesh, 2004).

The exploration of technology adoption through seminal models has illuminated various aspects of how organizations and individuals interact with new technologies. And provided a basis of key factors and dynamics to consider at the time of analyzing technology adoption. However, this journey has also uncovered significant inadequacies in underlying premises within these models, in regard to their applicability to our research context:

1) **Linear Process**: The traditional view within models like DOI, TOE, TAM, and UTAUT often characterizes the adoption process as a linear progression from initial awareness to complete implementation. This perspective, however, simplifies the inherently complex and recursive nature of adoption, where organizations engage in continuous cycles of exploration, experimentation, and adaptation. The linear assumption does not reflect the dynamic processes organizations navigate, iterating through stages based on feedback and evolving requirements. This calls for the development of frameworks that portray adoption as a flexible, dynamic process, capable of accommodating feedback and change over time (Clark et al., 2019). Future frameworks should therefore integrate the concept of engagement post-adoption, capturing how technology use leads to organizational evolution and how feedback loops between technology acceptance and adoption can further inform and refine technology strategy (Baaren et al., 2011).

2) **Top-Down and Rigid Decision-Making**: The emphasis on a top-down approach to decision-making within existing frameworks often marginalizes the crucial role of bottom-up feedback and the participatory involvement of end-users in the adoption process. This oversight neglects how the insights and experiences of those who directly interact with the technology can significantly influence, and even drive, the adoption decisions. A shift toward frameworks that recognize the intricate relationship between leadership decisions and user feedback is necessary, highlighting the collective

influence on technology adoption decisions (Röcker, 2010). Janssen and Van der Voort (2020) further argue for the importance of decentralized decision-making, especially under crisis conditions, indicating a shift towards models that recognize the collective influence of leadership decisions and user feedback on technology adoption, highlighting the need for agile and adaptive governance.

3) **Interplay with Organizational Processes**: A critical oversight in traditional adoption models is their failure to account for how technology adoption is deeply intertwined with changes in organizational processes. The introduction of new technology demands not just user acceptance but also significant adjustments in workflows, roles, and the organizational culture itself. This dynamic suggests successful technology adoption involves managing the transformation in organizational practices as much as integrating the technology. Models need to reflect the continuous interplay between technology adoption and organizational change, highlighting the necessity for frameworks that consider the organizational evolution driven by technology integration (Frambach & Schillewaert, 2002; Ifenthaler & Egloffstein, 2020).

In the highly regulated industry of pharmaceutical manufacturing, traditional technology adoption models such as the Technology-Organization-Environment (TOE) framework and the Technology Acceptance Model (TAM) might initially appear adequate for assessing technology adoption. These models assume a structured, top-down approach to decision-making, which is aligned with the regulatory and compliance-driven environment of the pharmaceutical industry, where technology use is often mandated by organizational policies (Tornatzky & Fleischer, 1990; Davis, 1985). However, their applicability becomes significantly limited under more dynamic conditions, as it is the case with crises.

Crises necessitate a departure from linear progression and centralized control, requiring a move towards agile and adaptive governance (Boswell et al., 2021). As well as an increased role of individuals and groups in the adoption and innovation processes to cope with the crisis, leading to a reevaluation of traditional operational procedures (Janssen & Van der Voort, 2020). Under crisis conditions, organizations are pushed to adapt their workflows and streamline their decision-making, which might include the rapid integration of new technologies to meet emerging challenges. These dynamics are very different from the structured processes envisioned by traditional adoption models (Obrenovic et al., 2020). Thus, while traditional models provide foundational insights into technology adoption, their utility is constrained under crises, highlighting the need for new frameworks that embrace the complexity, urgency, and adaptability required in such contexts.

3. METHODOLOGY

3.1 Research Approach and Design

Due to the scarcity of empirical studies on the adoption of AR technology within pharmaceutical manufacturing, as well as studies exploring the effects of exogenous forces on technology adoption, an exploratory approach was taken. The core methodology for this study is grounded theory, as proposed by Corbin and Strauss (1990). It is an inductive approach that intends to not force the data into a particular set of preconceived hypotheses, but rather allow the theory to emerge (Kenealy, 2012). A key reason for selecting this methodology is its appropriate fit with the study's intent, since it seeks both to "uncover relevant conditions" and to "determine how the actors respond to changing conditions" (Corbin & Strauss, 1990, p. 419).

A cross-sectional semi-structured interview study was chosen to unveil greater richness on the dynamics and reasons behind the observed behaviors (Saunders et al., 2016). Semi-structured interviews allow for depth and flexibility, crucial for exploring complex processes and acquiring detailed narratives (Saunders et al., 2016, p. 318). While cross-sectional data provides a snapshot of a single point in time, it captures detailed accounts of participants' experiences and perceptions. Participants' retrospective accounts offer insights into changes and adaptations over time. Similarly, interviewees had different levels of exposure to AR, with some participating in projects that had just received access to the technology, and others having conducted several projects that incorporated AR technologies into the core processes.

"Since phenomena are not conceived of as static but as continually changing in response to prevailing conditions, an important component of the method is to build change, through process, into the method" (Corbin & Strauss, 1990, p. 419). To achieve this end, several strategies were implemented: Memos were kept in order to capture individual evolving thoughts and conjectures. Discussion sessions were held throughout the interview process among the research group, in order to compare and contrast perceptions and emerging theories. Questions and prompts were adapted based on emerging insights. By leveraging grounded theory, we were are able to integrate participants' experiences and the contextual factors influencing them, thus providing a comprehensive understanding of the dynamics at play; as well as allowing for the generation of new theory, by analyzing these rich narratives to uncover themes and patterns that reflect dynamic processes.

This study is embedded in a larger research project investigating the role of AR tools within pharmaceutical manufacturing. The project includes a postdoc, two other masters' students, and a PhD student who worked for the MNC. Grounded theory is an approach not only appropriate but desirable to work alongside other researchers, opening the possibility to conduct collaborative analysis and increasing the scrutiny of the analysis to guard against personal biases (Corbin & Strauss, 1990).

All interviews included two interviewers: a principal interviewer, who led the conversation, and a secondary interviewer, responsible for recording the conversation, taking notes, and asking additional questions towards the end of the interview to ensure all questions from the guideline were covered, as well as emerging themes from previous interviews. The interviews were conducted by the Postdoc, the PhD student, and myself, with the interviewer roles rotating between us. At the time of the data collection, I also had a role as a research assistant to the Postdoc. Thus, I also served as the project manager for the research project. My responsibilities included managing the data, transcribing and anonymizing interviews, ensuring timely task completion, conducting additional research, and leading discussion sessions. The initial phases of data analysis were a collaborative effort involving all five researchers, while the final stages were conducted individually. Detailed descriptions of the coding stages are provided in the data analysis section.

3.2 Research Setting

This study aims to explore the factors and dynamics of the adoption process of AR technology in the pharmaceutical manufacturing industry, within the context of overcoming the COVID-19 restrictions on in-person interactions. More specifically, it focuses on a German Multinational Corporation (MNC) that operates as a Marketing Authorization Holder (MAH) of pharmaceuticals and three Contract Manufacturer's Organizations (CMOs) based in Europe and North America, which operate as partners to the MNC, producing and distributing drugs within their specific geographies.

Maintaining knowledge transfer processes between the MNC and its partner CMOs is indispensable to keep operations up and running. Additionally, there is an expectation by the MNC of a double-digit increase in net sales with its CMO network within the next five years, as well as a significant increase in planned projects. Thus, it was crucial for all companies in the sample to adapt quickly towards maintaining the existing knowledge transfer projects and planning future projects under the new status quo.

The knowledge transfer projects between the MNC and CMOs relied on TCMs for the earlier stages, including emails, phone calls, videoconferences, and other digital channels. For the later stages, the process relied on PCMs, entailing employees of the MNC physically traveling to the CMO sites to ensure that quality standards were being met in terms of outcomes and processes, the training of operators, as well as informal interactions which works as an additional channel for tacit knowledge sharing. Considering PCMs were no longer possible, AR emerged as a TCM alternative that permitted greater transmission of tacit knowledge than previously used TCMs. Particularly, because the technology permitted to show the employees of the MNC the on-site operations through a hands-free device, while interacting in real time and allowing the MNC employees to use AR features such as projecting documents or shapes into the visible fields of their CMO counterparts, as well as voice control.

Since several knowledge-transfer projects were already being executed, it was no longer possible to plan in advance the incorporation of AR devices. Instead, the adoption of the technology occurred simultaneously with the execution of the transfer projects. Even though the MNC had previous explorations of incorporating AR within their operations, these were merely punctual and mostly restricted to technology experts. The sudden imposition of COVID-19 restrictions limiting in-person interactions propelled all the companies in the sample to adapt as quickly as possible, creating a scenario where the implementation was supported by the leadership but through decentralized initiatives. This study was initiated with the intent of focusing exclusively on the later stages of predetermined knowledge-transfer projects. Yet, it became quickly apparent that there were other use-cases. Our scope broadened to consider the multiple applications of AR technology within the sample, both as solutions to processes that previously relied on PCMs, as well as processes that emerged through the implementation process enabled by the new opportunities provided by the access to AR technology.

3.3 Research Sample

The sample, consisting of 22 participants, was selected through purposeful sampling, a method advocated by Suri (2011), to ensure covering a variety of functions within the organization. This selection was facilitated by the PhD student, who is a part of the larger research project, and works at the MNC. The main criterion for selecting the sample was representativeness, understood as "breadth and variation" (Alvesson & Ashcraft, 2012, p. 247). More specifically, trying to cover the different expertise and roles of individuals involved in the knowledge transfer process who had been involved in the on-site pilots with remote assisted technology, either as direct users of the technology, involved in the coordination of the interaction, or playing an active role in the implementation of the technologies. Another important criterion was quality, understood as those "with the 'right' experiences and an ability and willingness to communicate these" (Alvesson & Ashcraft, 2012, p. 247).

Table 1: Sample composition

Role, Department	**MNC**	**CMO**
Manager, Projects	4	6
Technology Expert, Manufacturing	4	1
Industry Expert, Quality	1	0
Industry Expert, R&D	1	0
Manager, CMO Coordination	1	0
Manager, Information Technology	1	0
Leadership, Projects	0	2
Operator, Manufacturing	0	1

From the total of 22 participants, 12 worked for the MNC based in Germany, Norway, or Switzerland, representing leadership roles, middle management, technology experts, and industry experts focused on Quality Assurance (QA) or Research and Development (R&D). The remaining 8 participants worked for one of the 3 selected partner CMOs, the other 10 participants worked for the CMO partners in France, Italy, or the USA, covering leadership, management, and shop floor operator functions.

Managers are most prevalent in the sample. The managers at the CMOs – in addition to floor operators – are generally the responsible parties for using or wearing the devices that enable remote assistance in order to showcase the machinery, processes, and products at their manufacturing facilities. As well as coordinating, with their MNC counterparts, the different stages of the process and the specific interactions enabled by remote assistance technologies. Thus, they hold valuable insights regarding both the execution and the implementation of these technologies.

Industry experts consist of scientists and engineers who hold relevant knowledge regarding the technical aspect of the manufacturing processes. They are not involved directly in the coordination of the knowledge transfer process, but rather focused on ensuring replicability of processes and quality of the end product. Yet, since they hold greater technical expertise, they can provide richer and more context-specific insights.

Finally, technology experts from the MNC side will help contextualize the functionalities of the devices and their implementation. They have also been involved in user training, as well as facilitating the technology set-up for the interaction, and the implementation of the technology within the organizations.

3.4 Data Collection

For this study, interviews are the main data collection method. In alignment with grounded theory, which does not specify a particular structure for interviews due to its flexibility across various methods, we opted for a semi-structured approach. This approach was developed with guidance from Alvesson and Ashcraft (2012) and King (2004).

In order to conduct exemplary research using grounded theory it is important to be exposed to the empirical context (Suddaby, 2006). In line with this, a first step before the interviews was to conduct a series of informal conversations with the point of contact within the studied MNC – the PhD student who is part of the larger research project – to understand the internal processes, concerns, and expectations of the organization and of employees according to their role in the organization. The output of these interactions was a document on general context, covering the stakeholders and objectives, and another on the knowledge transfer process as they existed prior to the implementation of COVID-19 restrictions. These initial documents allowed to create a shared context and facilitated the onboarding of new researchers into the project.

Participants were emailed, briefed, authorized by their respective organizations, and finally interviewed online for 60 minutes. The interviews were held over a two-week period through online videoconferences considering the geographical dispersion of interviewees.

The interviews were conducted with the support of a guideline which covered 1) experience and expertise 2) attitudes towards the technologies 3) relational aspects. The interviews started with open-ended questions, to enable respondents to tell their stories and establish their concerns (Kenealy, 2012). A set of probes were included in the interview guidelines, but additional prompts were utilized in order to collect information pertinent to the area of study.

The interview's audio was recorded, then transcribed with the assistance of professional transcription software and anonymized. Resulting in around 250 pages, not considering interviewee notes and memos, as well as additional documents. The research team also had access to confidential documents about the planning and usage of AR technology in order to contextualize and verify the applicability and correctness of the participants' interviews (Rowley, 2002).

3.5 Data Analysis

The analysis of the data took place in parallel with its collection. Memoing was maintained, as it is a fundamental practice for grounded theory (Kenealy, 2012). Some of the key memos developed were: a coding journal, a memo of emerging insights, and a communal memo for clarifications that included unclear or industry heavy quotations. The transcripts were then coded using ATLAS.ti Software in four steps, the first two involving all 5 researchers, and the latter two conducted individually.

Phase 1 - Open Coding: The initial phase of open coding was executed as an 'interpretative process', where data was meticulously fractured to identify preliminary insights and concepts (Corbin & Strauss, 1990). The five researchers collaboratively delved into the transcripts, embodying the multi-perspective approach advocated by Alvesson and Ashcraft (2012) to enhance the depth of analysis. These first-order codes emerged from the raw data, where at least two researchers coded each interview through an iterative process that allowed for the retrospective incorporation or modification of codes.

Phase 2 - Axial Coding: The second phase, axial coding, involved the collaborative development of second order categories and subcategories (themes). Saunders, Lewis, and Thornhill (2016) emphasize this as a crucial step in clarifying the research trajectory. This process implied the codification of second-order themes through grouping and connection of the codes developed in the first phase. This round adhered to the principles of inter-coder reliability, again with each interview being coded by at least two researchers to solidify the validity of the findings, a process also supported by King (2004).

Phase 3 - Reputed Axial Coding: In the third round, a reputed axial coding was conducted, no longer in collaboration with other researchers but instead at individual level, in order to create categories more closely aligned with the focus of this study. This stage also allows for "theoretical refinement of categories" (Kenealy, 2012). This individual analysis is integral to the iterative nature of grounded theory coding, ensuring adherence to the evaluative criteria of Corbin and Strauss (1990).

We present the results based on the outputs of the data analysis from the three phases described. For a detailed visual representation, refer to the *Summary of findings* presented in Figure 3 in the Results section. Once these codes were contrasted with technology adoption and acceptance literature, discussing the implications of our findings, our analysis goes a step further.

Phase 4 - Selective Coding and model development: We identify an emergent central theme (*Openness*) with three core properties (*Decentralized, Iterative, and Adaptive*) that are present throughout the codes. We then go back to the second order subcategories (themes) and conduct selective coding around the central theme or core category (Corbin & Strauss, 1990). This stage is vital for condensing extensive raw data into a comprehensible story, capturing the empirical essence of the study, and aiding in new model development that can assist in the understanding of the observed phenomena (Corbin & Strauss, 1990; Gioa et al., 2013). Several codes that emerged in the initial stages were discarded due to falling outside of the scope of the central theme. Care was taken to avoid conceptual stretching, focusing on distilling a core category that encapsulates the central phenomenon of the study authentically" (Suddaby, 2006). For a detailed visual representation, refer to the *DIA model of Open Adoption* presented in Figure 4 in the Discussion section.

It is important to note that no correlational relationships can be objectively established beyond subjective inferences, instead the objective was to shed light into a phenomenon not previously investigated within the defined context of this study, and to uncover underlying dynamics that could aid in the development of new theory.

4. RESULTS

Figure 3 below presents a summary of the findings. We present the most pertinent insights of the first order codes that emerged through open coding (Phase 1). We then present the second order themes and their aggregate categories that were determined through axial coding (Phase 2) and then refined through reputed axial coding (Phase 3). This approach is informed by previous research with similar methodologies (Van Burg et al., 2014; Brock et al., 2020). Insights and categorizations were selected and refined to facilitate the storytelling process, allowing on one side to connect the findings to the literature, and on the other serving as a basis for model development.

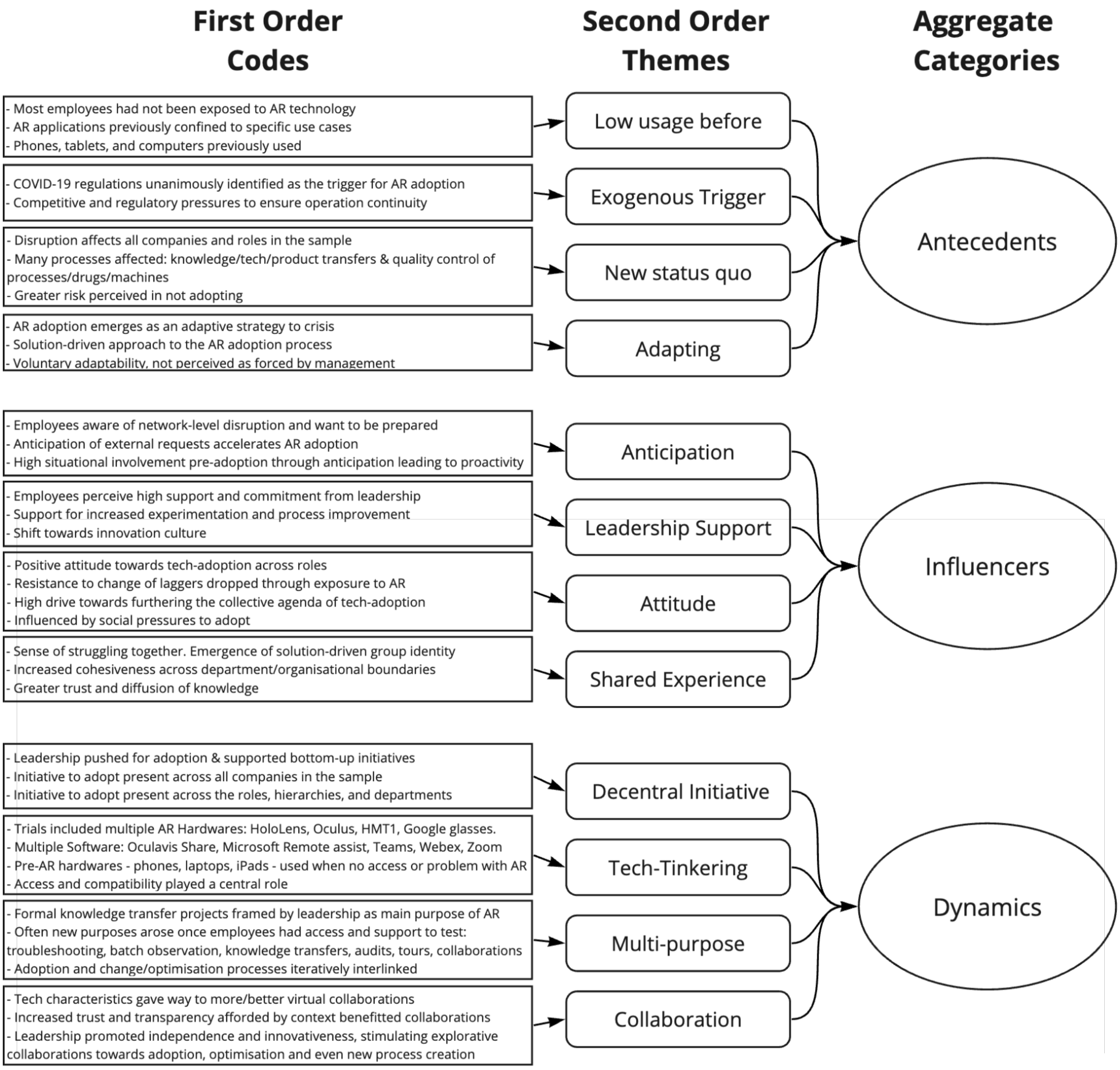

Figure 3: Summary of findings (Own representation)

We first cover the antecedents that lead up to the adoption process, which show the importance of the context that contained the adoption process. Then we focus on the influencers, where we look into key adoption factors, allowing us to draw connections to the technology adoption and acceptance literature. Finally, we delve into an exploration of the characteristics of the adoption dynamics, which seem to be distinct to previous adoption approaches, and how they were influenced by adoption factors

4.1 Antecedents

4.1.1 Low Use of AR Pre-pandemic.

The adoption of remote assistance technologies, such as augmented reality devices like the HoloLens, was relatively uncommon prior to the COVID-19 pandemic. The application of such technologies was largely confined to specific use cases. For example, one interviewee mentioned a situation where remote assistance was employed:

> *They did it before COVID. I remember it was the ones which are responsible for explosion safety ... normally they flew in and they wanted to try to be faster and more cost efficient by not having always an expert to fly in* (Technology Expert, Manufacturing, CMO).

Some had sporadic exposure to these technologies in a professional context:

> *It's my first experience with this technology. And at that we just introduced this technology for another project. I used this technology only for demonstration maybe five years ago in an industrial meeting. So I'm aware of what this technology [is], but I didn't use this technology before last year* (Manager, Projects, CMO).

These instances were exceptions rather than the norm, indicating a low level of utilization before the pandemic. Despite some punctual instances of AR use, most interviewees had not engaged with the technology in a professional setting before the pandemic. One interviewee reflected on their initial encounter with these technologies: *"it was two weeks ago ... my first time to use this device"* (Industry Expert, Quality, MNC). A similar sentiment was echoed across manufacturing facilities where operators were using the technology for the first time: *"they're absolutely not used to it. So they never used it before"* (Technology Expert, Manufacturing, MNC). Similarly, another shared: "*He had never seen the goggles before. He had never seen the instrument before, he had never spoken to the technicians on the other end before. So it was a lot of new impressions for him"* (Industry Expert, R&D, MNC). Even the use of other virtual communication technologies not based on AR was novel: *"Before with my counterpart, we used to phone ... since the pandemic, we use the camera"* (Manager, Projects, MNC). This change indicates a broader transition towards more immersive collaboration, further underscoring the limited pre-pandemic deployment of these technologies.

4.1.2 COVID-19 Restrictions Trigger

The abrupt acceleration in the adoption of remote assistance technologies can be attributed to the COVID-19 restrictions on traveling and social distancing. The sudden necessity of finding alternatives to traditional, in-person interactions brought these technologies to the forefront. Individuals across different companies and roles unanimously highlighted the pandemic as the root cause of this swift transition. For example, one interviewee stated: *"This was definitely brought on due to COVID. The preference before COVID was to have customers come on site ... Now they're doing it all the time"* (Manager, Projects, CMO). Another echoed, *"the COVID, the lockdown measures. Yes. And that's why our client couldn't come here and usually these transfer runs are made with the client"* (Manager, Projects, CMO). This shared understanding among individuals from various companies and roles underscores the collective acknowledgement of the pandemic's impact and the resulting urgency to adopt remote assistance technologies. As succinctly summarized by one participant, *"The root cause* *for doing these observations was strictly due to the COVID-19 situation and the team's inability to travel"* (Manager, Projects, CMO).

4.1.3 New Status Quo for Whole Industry

The COVID-19 restrictions profoundly impacted a wide array of roles and processes, effectively introducing a new status quo with unique needs and emerging requirements. For instance, one participant underscored this impact, saying, *"This year due to the COVID situation, we can't travel to CMO and can't perform onsite audits"* (Industry Expert, Quality, MNC). The pandemic-driven restrictions significantly disrupted previously routine practices and processes, with another interviewee highlighting: *"They would have been onsite for that whole campaign for the whole time, if it wasn't for COVID"* (Leadership, Projects, CMO). The pervasiveness of this new reality was felt across all roles and instigated a substantial shift in operations. This shift necessitated the reevaluation of traditional processes and the search for alternatives that allowed for key processes to continue.

4.1.4 Adopting to Adapt

Faced with the new status quo, adopting remote assistance technologies emerged as an adaptive response. As one participant put it, *"It's necessary, we need it. We need a solution for this COVID-19 crisis. And one solution is remote assistance, so we use it"* (Technology Expert, Manufacturing, MNC). This urgent need for alternative solutions is echoed by another participant:

> *With this COVID issue, it was just very matter of fact that we had to find another solution to batch observations. So really the operators and the people who had to utilize the equipment they were kind of forced into it, I would say* (Manager, Projects, CMO).

It's essential to clarify that the term 'forced' in this context signifies the compelled adaptation induced by the new status quo, not a coercive decision by the management. As such, the adoption of remote assistance technologies emerged as a practical and necessary adaptation to maintain operational continuity in the face of the new, pandemic-induced reality.

4.2 Influencers

4.2.1 Anticipation

Beyond the pandemic's immediate impact on internal processes, the disruption permeated throughout the entire pharmaceutical industry affecting processes at network level. Given the universal reach of this disturbance, coupled with its widely acknowledged presence, another dimension surfaced as part of the trigger: the anticipation of external requests and expectations.

A key insight from the data reveals that even before facing any explicit technological demands from clients or partners, there was a palpable sense internally of impending requests. One participant mentioned:

> *It was kind of the anticipation because we already have customers that we expect to see in person, whether it be for a business related meeting or an observation of something happening in manufacturing. So there was already, I mean, the first time I heard about it was internally, not from a customer, like directly, personally. Okay. And what tools did we have available to, you know, accommodate an anticipated request* (Leadership, Projects, CMO).

This suggests an acknowledgment of the new status quo that was arising and an attunement to the broader shifts in the industry, where the expected interactions with clients and partners would undeniably be altered. Moreover, this anticipation was not only rooted in the mere use of technology but also the necessity of its adaptation to satisfy partner and client expectations in the new normal. As expressed by an interviewee:

> *And we mentioned that how a customer needs to have this technology you choose as a COVID situation. It's very important for our customer, to see what's happened during the execution of the technical trials or GMP batches so it's a new technology. And the improvement of this use is very important in this situation due to the COVID* (Manager, Projects, CMO).

The conversations revolved not just on how to adapt to the new status quo to continue internal processes and interactions with partners, but also on how a solution might be integrated with the processes of external entities, ensuring a smooth continuity in processes.

> *I was majorly interested in also understanding and communicate with the external party, you know, what kind of requirements must they meet? So, I mean, it's one thing that we explained what we want to have, but of course, for me, it's important if it's feasible to be implemented at the external companies* (Manager, CMO Coordination, MNC).

It is worth noting that the sentiment of anticipation was present throughout the partner network. CMOs also anticipated the implementation of new technologies and the development of new processes to overcome the limitations of COVID-19 regulations: *"I think with [CMO-1] as they were already kind of prepared that wasn't so much a problem because they already knew* (Leadership, Projects, CMO).

While the pandemic's immediate disruptions served as an undeniable trigger, it was coupled by the weight of the evident repercussions of the foreseeable future, attuned to the future expectations and demands of partners and clients. This dual-trigger – both the immediate internal disruption and the foresight of upcoming external requests – underscores the industry's adaptive approach during these uncertain times.

4.2.2 Attitude

The new status quo paved the way for a paradigm shift in attitudes towards the adoption of AR technologies. Employees found it more digestible to understand and appreciate the potential value of such tools. As one noted, *"I think due to COVID, it's been a bit easier for people to swallow or acknowledge the use of such a tool. The whole situation really promoted that"* (Manager, Information Technology, MNC). This shift was not limited to a few, as evidenced by another comment: *"I think acceptance is rather high. It depends on how open people are, but I've never heard anyone saying, 'I don't want to do that, I'm completely against it'"* (Technology Expert, Manufacturing, CMO).

Where there was resistance, it was more attributed to a gap in competence than a reluctance or negative disposition towards change. Drawing a distinction between different user types, one employee shared, *"There are always the novices and the experts, and then there are also the front-runners and laggards. I've observed both, but if front-runners are around 90%, the laggards are merely 10%"* (Manager, Projects, MNC).

Some initial concerns were expressed regarding intermittent connectivity within the industrial facilities and tiredness after prolonged use due to the weight of the devices. Yet, these concerns did not have an influential impact on the attitudes towards the technology. Employees, regardless of their specific roles, exhibited an overwhelmingly positive outlook towards the technological shift. They weren't just passive participants but were actively curious and enthusiastic about the adoption process. One manager stated, *"They were more curious to try these kinds of tools ... No concern from my people"* (Manager, Projects, CMO). This sentiment was echoed in the observation, "The engagement was high, with lots of enthusiasm and curiosity from users. There was no negative attitude. Everyone was positive about using this technology" (Manager, Projects, MNC).

Beyond mere acceptance, employees foresaw the tangible benefits that such technological integrations would bring. One of them optimistically shared, *"Everybody is very open to this technology, believing it will improve collaboration and the overall situation"* (Technology Expert, Manufacturing, MNC). The sentiment was complemented with the notion that these tools weren't just for the present but would be instrumental in forging future relationships through the partner network, as summed up by, *"With these new virtual tools that everyone is adopting, it's going to facilitate and further bolster the relationship"* (Manager, Projects, CMO).

4.2.3 Leadership Support

The need for swift adaptation to the new status quo elicited increased support from company leadership for the adoption of new technologies. On interviewee noted:

> *It was very interesting to have help from the corporate because by ourselves, I don't know if we could have this idea, everybody knows how to use and how we can use a smartphone, but it's not the same quality, it's not as interactive* (Manager, Projects, CMO).

The shift in support was evident to employees, with one noting that it might not have been as forthright under normal circumstances: *"I'm not sure that the support would have been there, had it not been for the COVID situation"* (Manager, Projects, CMO). Employees were generally excited about the support provided by leadership, recognising it was indispensable:

> *I think it's, it's the leadership that we have it here. They are more positive engaged towards the new trends and technologies. So it's all coming from there, from someone from the leadership, like, they are very much committed to have this in place, to see what kind of value it brings you know embrace the future and stuff* (Technology Expert, Manufacturing, CMO).

Under this atmosphere of supportive leadership, employees felt they had the freedom to innovate and embrace an out-of-the-box approach towards problem-solving:

> *Our management is very supportive and then that gave us the freedom to go out of the box and then create a kind of a new operating model, which is giving that, you know, that push or that kind of positiveness to the project* (Manager, Projects, CMO).

Rather than having to follow stringent protocols which are common in the industry, employees now had the autonomy to experiment.

4.2.4 Shared Experience

Across companies and departments, employees found themselves grappling with similar challenges as a result of the pandemic. Being affected by the same disruptive event engendered a sense of togetherness, which brought people closer. As one person said: "*I think we have a very good relationship, I would say because we're struggling with these issues together and all this COVID situation for us (…) you're together in this situation and you together want to make the best out of it*" (Technology Expert, Manufacturing, MNC). Another echoed this sentiment:

> *We also have a shared, going through this and being in this situation together where not only can they not come, but we can't allow them to come. You know, it's on both sides. So I feel like the shared experience has created deeper relationships. So I have not seen a decline at all* (Leadership, Projects, CMO).

Interviewees noticed that their counterparts were being more empathetic with them and more patient with the outcomes of the interactions:

> *This was just something that everybody had to get used to. And I think that there were other customers who recognize that we're trying to get this up and running and when everyone got put on quarantine and I would say in early March, I think everyone recognized that we were doing the best that we could at the time, but when [MNC] was ready to do their observations, which was late May, June timeframe, you know, again, we had gone through those hurdles with other customers. And I wouldn't say that the hurdles negatively impacted our relationship. But it was just very clear to both parties that we needed to figure out a better way to do this and to help facilitate* (Manager, Projects, CMO).

The dynamic wasn't the usual client-provider relationship. Instead, it resembled a collective with everyone working towards a common goal and sharing ownership of the process. The focus was not placed on the specific roles or responsibilities, but rather focused on finding solutions that would ultimately be beneficial to all parties. This is succinctly expressed by an employee that pointed out, *"I think we have a lot of faith in, also the working of one another. And so if someone makes proposals, we are very open always to any kind of proposal. And it's a very solution-driven relationship"* (Technology Expert, Manufacturing, MNC). Employees had great disposition to interact across departments and companies, going outside their defined roles, assuming a proactive role in the technology adoption process.

4.3 Dynamics

4.3.1 Initiative

The integration of AR technologies during the pandemic spanned multiple layers of the organizational structures of the MNC and its CMO partners. It was evident that the impetus for adoption was not restricted to one level or function but rather decentralized across the organizational hierarchies and roles. There was clear evidence of the leadership's drive and support towards AR adoption. An individual noted, *"It was very interesting to have help from the corporate because by ourselves, I don't know if we could have this idea"* (Manager, Projects, CMO). However, it wasn't solely an upper management directive. The narrative coming from employees painted a picture of grassroots innovation. For instance, a project manager from the MNC peripheral site in Oslo mentioned:

> *I thought like this mixed reality or augmented reality, you could see the whole process right in front of you in a photographic image. And it's, step-by-step instructions might be one possible solution for us in transferring the knowledge without traveling to the sites and without conducting workshops. So it all started from there and there was a lot of positive commitment and engagement from our management team here* (Manager, Projects, MNC).

Similarly, from an MNC site in Switzerland, the emphasis on the tangible benefits of AR was evident as another manager relayed, *"It was me requesting it because I thought it was much easier for us to see it, like on a video stream rather than a few pictures or, and we could not travel"* (Manager, Projects, MNC).

Moreover, IT specialists within the MNC also took a proactive stance to initialize the adoption process. As one expressed:

> *I just triggered the discussion back in time with some tech transfers on the beginning of the pandemic situation due to the fact that we saw a potential delay of some of the projects, then there was when we started talking about possibility that we would have some new technologies, and then there was how this discussion on AR came to the table* (Manager, Information Technology, MNC).

On the CMO side, a similar interest in AR was observable. One comment highlighted:

> *I think a lot of the ideas came here at our company just because yeah, so many different like I said, like a lot of our different clients, I wanted to still have some sort of like, be able to view their batches and there's just so many restrictions of them coming on the site because of the pandemic* (Operator, Manufacturing, CMO).

Further exemplifying the broad range of initiators, there was an account detailing that "*It was the director of packaging, worldwide director of packaging in us who, yes. He knows that we were using this HoloLens on the other application, I start using it and then after having received them"* (Manager, Projects, CMO).

Overall, the adoption of AR was not solely driven by a single entity or a particular level within organizations. Instead, it arose from a collaborative realization across different roles, departments, and hierarchies, all recognizing the pressing need for technological solutions during an unprecedented period.

4.3.2 Technological Tinkering

The adoption process did not revolve around a single technology, instead *"there is still not a kind of established technology*" (Manager, Information Technology, MNC). Employees utilized an amalgamation of AR devices in order to maintain communication and collaboration processes including the HoloLens, Oculus, HMT1, and Google glasses.

At times accessibility to specific hardware determined the technological choices. An employee recounted, *"We had additional events planned, so we were thinking to use Oculavis instead of Teams, but with the mobile phone. Because the device was still being ordered and it didn't arrive yet at that point in time. And we had a run planned for the next day*" (Manager, CMO Coordination, MNC). In order to ensure continuity, even in the absence of AR specific hardware, the tinkering extended to even laptop cameras: "and not only the use of the HoloLens was good because you could get very close, but we also utilized just the laptop, computer cameras and had those stationary which wasn't very helpful because you couldn't get, they weren't able to set it up close enough to the equipment for it to be beneficial for the observers" (Manager, Projects, CMO). Other times it was driven by compatibility of the new AR devices with the current infrastructure:

> *We have had some connectivity issues with the technologies, I think in some of the areas you know, some of those internet connections could be improved. So essentially what we did for the [MNC] project so far is we, instead of using this HoloLens headset, we got a tablet similar to iPad* (Operator, Manufacturing, CMO).

Given that the AR technology was utilized as a TCM for knowledge sharing, it had to be simultaneously deployed in at least two different locations. Thus, the issue of compatibility was not in regards to the existing infrastructure in one company, but instead extended to the partner network: *"They sent us some Google glasses, but it was not working correctly. (…) when we said we had the proper system [HoloLens], they were very happy to hear that"* (Manager, Projects, CMO).

Compatibility issues also extended to the physical space, with limitations such as quality control stipulations affecting useability. One interviewee explained that *"At the beginning, we need to add your computer. And if we move onto the manufacturing area due to the cross-contamination, I cannot introduce my computer"* (Manager, Projects, CMO). The counterpart of the user utilizing an AR headset has to be connected to a computer requiring some specific software, so there is also the issue of compatibility with different software for virtual communication such as: Microsoft Teams, Webex, and Zoom, as well as software specific to the AR hardware such as Oculavis Share and Microsoft Remote assist.

Another reason to resort to previous generation hardware was comfort, both in terms of familiarity and ease of use:

> *If they do use it via a smartphone, if it's, something, which then they know how to interact, and they know how to do, their acceptance is extremely high (…) using smart glasses (…), it's the thing that you have to put a thing on your hat, which is, might be heavy, then it's also the interaction is completely different as you interact with such a device either by voice where I have to say the acceptance is rather good there that people learn fast and then are well really confident with that* (Technology Expert, Manufacturing, CMO).

In the course of tinkering with various new technologies and devices, employees had the opportunity to develop preferences based on the usefulness of such tools with regards to their real-world applications:

> *I like the HMT1 because it's easier to use. you get all the information you need to see a little video, you see some instruction, whatever it's very easy to use. The HoloLenses is more fancy to see something in front of you, what doesn't exist is of course it's exciting, but for remote assistance, it doesn't help you* (Technology Expert, Manufacturing, MNC).

In conclusion, rather than following a linear path of integrating one solution, the employees' strategy revolved around tinkering through iterative trials. Instead of a monolithic technology, there were a myriad of tools utilized and tested in real-world scenarios. Technology choices were driven by the immediate availability of devices, the technologies compatibility with the existing physical and digital infrastructure at a network level, the familiarity and comfort of users to the different software and hardware, and their usefulness. Ultimately, this freedom to tinker with different devices and configurations enabled employees to identify the best fit for their particular use cases.

4.3.3 Multi-purpose

Similar to the tinkering around the technological choices, where different technological configurations were tested, we observed a process of tinkering around the uses of AR. The trigger for the implementation of AR was often attributed by leadership to a specific need: *"So [using the AR-device] was done for that purpose … to give an impression of what is the manufacturing process flow and what kind of equipment in each condition is installed"* (Manager, Projects, MNC). However, once within the organizational ecosystem, employees rapidly began to recognise and explore its broader capabilities. Once employees had access to a technology they tested it in different ways, leading to the emergence of new uses and benefits, as well as possibilities to innovate on the pre-existing processes. A recurrent theme across the sample was the possibility of using the AR devices for troubleshooting. This would permit interactions between experts at the MNC and the CMO counterparts that previously required a PCM, increasing the response time and the frequency of knowledge sharing through TCMs.

> *I think it is good because we can have a real time feedback. So, we are facing issues say on the manufacturing, for example. Our customer can be there with us to help make decisions really quickly. I think that it does help with making the project more successful* (Operator, Manufacturing, CMO).

One example of troubleshooting was conducted between a CMO employee getting in contact directly with the manufacturer of certain machines, evidencing the capacity of AR to increase network connectivity beyond the initial expectation of interaction between the MNC and the CMOs (Industry Expert, R&D, MNC). While the implementation of the technology as a replacement of PCM in the later stages of structured knowledge transfer projects exhibited multiple previous interactions to decide on which technological configuration to use and train users, other applications that were not previously codified happened more rapidly and informally. A technology expert pointed to the possibility of using the technology to conduct machinery reparations (Technology Expert, Manufacturing, CMO). A manager remarked on the range of possible use cases, stating:

> *I think going beyond the tech transfer environment, I think that can be used for many different use cases, like really to operate a kind of a plant or like nowadays, I think when we have to deal with, let's say problem solving on the shop floor, or maybe to connect between two different companies or even between sites* (Manager, Information Technology, MNC).

Similarly, another This organic diffusion also manifested in how the technology permeated various departments and processes. An interviewee detailed how after introducing the AR device, its utility was recognized for multiple processes, both internally and externally.

> *I see a great chance in using this device, and for all collaborations, with this CMO, externally as well as internally. Yeah, after the introduction of that device, I wrote an email to my colleagues from the QA function and introduced them [to] the new device for using in audit or inspections as well. And I think it's a great chance for remote audits as well* (Industry Expert, Quality, MNC).

The users identified several additional processes that could benefit from adopting AR technologies and generally had the space to use the new technologies towards the most pertinent and beneficial purposes. The adoption journey revealed a model that isn't confined to a predetermined purpose but allows the potential applications of the technology to surface organically.

Employees were given the freedom and flexibility to explore the technology and use it in the context they deemed pertinent. It wasn't just about a tool at their disposal, but rather an asset they could mold and adapt to various situations. As one employee succinctly put it: *"Now you have freedom, you can take it whenever you want, you can use it wherever you want"* (Manager, Projects, MNC).

This evolutionary trajectory of technology adoption in our findings underscores the value of a flexible adoption process that refrains from pigeonholing the technology to a singular utility and instead encourages a dynamic integration, allowing the technology to organically find its most pertinent and impactful role and transform processes within an organization.

4.3.4 Collaboration

The adoption of AR technologies spurred an integral shift toward enhanced interdepartmental and inter-company collaboration. This was partially due to the technology characteristics, but also due to the adoption context, which called for an urgent collective engagement from various departments and companies. The collaborative essence of the adoption period ushered a constructive feedback loop, where the need for collective involvement facilitated deeper interdepartmental and inter-company collaborations, which in turn, enriched the process of adoption further.

A respondent reflected on the collaborative attitude among companies: *"The colleagues from the CMO were very open. They had an open mind and it was very good collaboration with these colleagues"* (Industry Expert, Quality, MNC). Such openness transcended organizational boundaries, as evidenced by another participant:

> *So we have a very open and honest discussion. So I'm always very straightforward and asking, are there any issues with the team, can I do something better to communicate better with our video team and so on? So it has always been on a level where we are looking for solutions and we are very transparent on problems. Yeah. So, and we had lots of problems. So, I think it's built on all these challenges and all this openness where the relationship is, it's good* (Manager, Projects, MNC).

Moreover, the process cultivated a sense of mutual learning and adaptation among the involved entities. A participant noted:

> *So we have been also kind of not educating, but cannot saying, okay, this is what we need. This is what you have to do. This is how we want to, too, so I think it's been a learning curve for them as well, and for us to adapt ourselves to provide the right expectation and the right. Yeah, so it has been a growing relationship, I would say. And something that's in some other symbols where they have really their way of dealing with their customers and just like, yeah, don't worry, we'll do it. And sometimes you don't get this openness. This is really particular as well (Manager, Projects, MNC).*

This established a conducive environment where fears of making mistakes were minimized, promoting a more candid dialogue. This sentiment is captured in the statement,

> *And also, yeah, discuss this in greater detail with them and asking another question, which, because of this open relationship, they are not afraid to, or they don't want to hide anything, or they're only open for that. So I think this, this really helps* (Manager, Projects, MNC).

Additionally, the challenges encountered were navigated through the collaborative framework that had been established. For instance, one respondent shared:

> *The feedback from that particular customer was that they love that technology so much so that, you know, they wanted to use it for everything. And so then we had to kind of do a little backpedaling when it was like a 14-hour day and they wanted the HoloLens in use. And so we had to figure out how we, how we addressed that specifically, but we have a collaborative relationship. So we were able to work through that* (Leadership, Projects, CMO).

The openness inherent in the adoption process allowed for a more agile, independent, and innovative approach, as encapsulated in a respondent's statement:

> *If you want to proceed with [the MNC] kind of solutions, then you have to, you know, create the kind of ticket for the central IT system. And they prioritize where they, it is highest or the lowest or in the middle. And then they come back to you like over weeks and they say like, we don't have an option and stuff. So what we did is like, we went out of the box. We, we try to overcome or, you know what you call them. I'm not remembering the word, but it's, it's like we, we came out of the box and then we have tried to establish our own solution from an external service provider* (Manager, Projects, MNC).

The manner in which the AR technology adoption unfolded fostered and was reciprocally enriched by an enhanced collaborative environment. This wasn't merely a procedural shift; it emerged as a collective endeavor, drawing from various organizational levels and extending beyond company boundaries. This decentralized approach not only sidestepped potential bureaucratic delays but fostered a more innovative and swifter adoption process. By stepping 'out of the box', the involved entities navigated through the adoption intricacies, in the process, reinforcing interdepartmental and inter-company relations. This collective venture through the adoption phase facilitated the realization of AR technologies and cultivated a collaborative ethos likely to have a lasting positive impact on organizational culture and relations.

5. DISCUSSION

5.1 Antecedents

In our research setting, the impetus for adopting AR technologies was the need for the continuation of operations in a new reality, where travel and physical proximity were no longer possible. The effects of the COVID-19 regulations on the pharmaceutical industry illustrate a broader trend, where external shocks can play a pivotal role in accelerating technology adoption. The future risk of pandemics is a significant concern, with experts indicating that similar or even worse outbreaks are bound to happen due to complex interactions between viral agents, the environment, and society (Coccia, 2023; Morens et al., 2020). Another critical challenge is the possibility that climate change disrupts global supply chains, including operational continuity. From the increasing occurrence and magnitude of climate-related events, such as wildfires and hurricanes, the pressing need for adaptive strategies, together with new technologies, cannot be overemphasized (Diffenbaugh & Field, 2013; Masson-Delmotte et al., 2021). Policy shifts in response to these environmental challenges might push industries to quickly adopt new technologies in accordance with the new standards or take advantage of the subsidies derived from sustainable practice (Porter & van der Linde, 1995; Jordan et al., 2013).

Further, the technological advancements themselves—especially those of disruptive potential—may also compel companies to adopt to keep competitive barriers high. The increased pace of innovation indicates that technological disruption is not only inevitable, but will take place at an accelerating rate (Schwab, 2016). It seems only logical that companies will require greater adaptability and agility in their technology adoption processes to maintain competitive advantage (Christensen et al., 2015). Given these potential triggers, the necessity for corporations to adopt new technologies as a mechanism for rapid adaptation, under considerable time constraints, is increasingly evident. There is a critical need to reassess and evolve traditional models of technology adoption so that they can reflect the nuances of rapid technological integration driven by environmental pressures (Kung & Kung, 2015).

Our results show that employees understood COVID-19 regulations as the trigger for the adoption process, rather an obligation coming from the leadership, assuming an adaptive approach to the new status quo where it was in their best interest to engage proactively with the adoption of AR technology. In line with recent research, as individuals perceived their engagement with technology as voluntary, they were more willing to engage, experiment and integrate the technology (Peng et al., 2019). Voluntariness of use has shown to be a positive factor in technology adoption, leading to increased satisfaction, performance, and positive attitude towards the technology (Dahabiyeh et al., 2020). It has also been found to influence other factors positively, increasing the perceived ease of use, usefulness, and intention (Widiantoro & Harnadi, 2019). In highly regulated industries voluntariness is often limited by compliance needs, and by rigid top-down organizational frameworks (Nisar et al., 2013).

Risk has been found to have an important impact on adoption intention. High levels of perceived risk can deter technology adoption even if the technology is perceived as useful (Martins, et al., 2014). In highly regulated industries – such pharmaceutical manufacturing – the perception of risk is related mostly to regulatory sanctions due to potential non-compliance, as well as IP protection concerns, which can oblige organizations to have a rigid strategy (Nisar et al., 2013). Similarly, AR technologies carry potential risks that can dissuade their adoption, including concerns about privacy and cybersecurity, physical safety concerns, and health risks to sensation and perception (Zhou, 2018; Sabelman & Lam, 2015, Baldassi et al., 2018).

The impact of COVID-19 regulation created a new status quo, where the traditional industry risks paled in comparison to the risk of not finding new solutions that could ensure operation continuity and competitive advantage. The risk of ceasing operations also had a direct effect on employees who could potentially lose their jobs and thus had a direct incentive to be a part of the solution. It is clear from our results that employees did not feel pressured by management, nor discouraged by the potential risks of AR technology, but instead assumed an adaptive perspective and a proactive approach to finding solutions. This is aligned with recent research on IT adoption in crises, where the immediate benefits of addressing the arising needs can outweigh the perceived risks, driving organizations to adopt new technologies despite potential long-term challenges (Pierri & Timmer, 2021).

5.2 Influencers

5.2.1 Anticipation

The anticipatory behaviors evidence a shift in the role that users play in traditional adoption models: from a reactive one in which the user only complies with the adoption of technology to a proactive approach in which the user takes a central role in driving the process of adoption (Davis, 1989; Rogers, 2003; Tornatzky & Fleischer, 1990). This approach promotes proactive learning and knowledge dissemination, which are crucial for an organization's capacity to adapt (Argote & Miron-Spektor, 2011). Through anticipation, individuals not only engage in acquiring and sharing new knowledge but also manifest adaptive performance that can be essential in managing change in the workplace environment and integration of new technologies (Pulakos et al., 2000). Proactive individuals are crucial in driving innovation and adaptation, enhancing the organization's capacity to navigate the complexities of technology adoption through effective learning and adjustment processes (Parker et al., 2006; Cepeda-Carrion et al., 2012).

This future orientation is not a linear stage but part of a feedback loop where the future informs present actions and decisions, and also affects the rigidity and permanence of current decisions. This works as the underpinning of the cognitive and affective dimensions to take a proactive stand of dealing with the emerging technologies. Cognitive factors can involve rational assessments of all the potential benefits and challenges linked with adopting AR technologies, while affective factors are all the emotional responses from excitement to anxiety for the anticipated changes that could happen in the future (Beaudry & Pinsonneault, 2010). This kind of anticipatory approach generates a sense of empowerment and responsibility, pushing individuals to actively participate in technology adoption (Spreitzer, 1995). The proactive stance, informed by a forward-looking perspective, is very critical in navigating the uncertainties of integrating new technologies, especially critical in rapidly evolving scenarios such as a pandemic like COVID-19.

The social dimension of anticipation illustrates how individuals, by foreseeing the needs and expectations of coworkers and external partners, play a pivotal role in technology adoption, linking personal initiative to collective efforts (Pierce et al., 2003). This underscores the notion that technology adoption transcends individual action, embedded instead within the broader fabric of organizational and inter-organizational dynamics, thereby making adoption a shared journey (Powell et al., 1996). In this way, users become key conduits in the adoption process, by strengthening collaborative networks beyond organizational boundaries which enhance technology integration. Furthermore, collaborative innovation research highlights how anticipation in joint R&D or innovation networks amplifies the perceived usefulness of new technologies, leveraging pooled insights, resources, and expertise to foster a shared understanding of the impact from the technology, thus increasing the chances of successful adoption (Chesbrough, 2003; Battistella, 2014).

In our setting, employees were inevitably involved early on in the adoption process, not necessarily through direct leadership intent, but by the mere fact that they were embedded in the context, aware of the need to overcome the arising needs of the new status quo, and voluntarily proactive towards finding solutions. Being involved in the adoption process early – i.e., having high situational involvement – seems to have positively affected the perceived usefulness, perception of ease of use, and intrinsic involvement; in line with previous research (Leso & Cortimiglia, 2022). Intrinsic involvement refers to a user's inherent motivation to use the technology not solely dependent on immediate external needs or demands, reflecting a more stable and enduring engagement.

5.2.2 Attitude

Classically, attitude has been viewed as a critical determinant of technology acceptance, heavily influenced by a user's previous experiences (Davis, 1989). Our findings reveal a complex interplay between attitude and anticipation. While attitude tends to look back into the past, pointing out how previous encounters with technology shape current acceptance levels, anticipation adopts a prospective look. This forward-looking nature of anticipation complements the backward-looking aspect of attitude and gives credence to the observation that the technology adoption process experiences a paradigm shift from reactive posture based on past experiences to a proactive stance driven by thinking oriented towards future. This nuanced relationship underscores the pivotal role of anticipating not only the technology's direct impacts but also its potential to meet evolving organizational and network needs with a greater connection to the implementation dynamics.

Upon the initial exposure of employees to AR technology within the organizations, attitudes towards AR were influenced by their previous exposure to the technology and their general attitudes towards technology. In other words, in which adopter category they belonged (Rogers, 2003). This suggests that while the majority exhibit a positive disposition, a small fraction may resist due to competency gaps rather than opposition to change (Venkatesh et al., 2003). These competency gaps seem to close through exposure to the technology, training, and social interactions, evidencing that attitude is an evolving factor and suggesting that enhancing organizational support could mitigate resistance and foster a more positive attitude towards adoption (Venkatesh et al., 2003; Karahanna et al., 1999). Moreover, the emphasis on the role of these technologies in fostering future relationships points to a broader understanding of technology adoption as a socio-technical process, where social factors and technological capabilities interact to shape adoption outcomes (Leonardi, 2011).

The COVID-19 pandemic catalyzed a significant shift in employee attitudes to technology adoption, towards a more open and positive outlook, moving beyond mere acceptance to recognizing the broader implications and benefits of the technologies (Davis, 1989). Employees' heightened curiosity and enthusiasm towards adopting AR technologies, as noted in our findings, align with the notion that attitudes towards technology are not static but evolve in response to external stimuli and changing circumstances (Venkatesh & Bala, 2008).

Our results show that attitude was not a fixed precondition of technology acceptance, but rather evolved throughout the adoption process. This is in line with empirical research in the last decade which has shown attitudes to be influenced by different factors at various stages of the process (Tverskoi et al., 2022). The change in the group identity towards a larger collective, fueled by a sense of togetherness, brought forth new configurations in the adoption rationales and attitudes, which have been shown to shift adoption decisions in collective settings over time (Bayerl et al., 2016).

5.2.3 Leadership Support

Leadership support played a pivotal role in the accelerated adoption of AR technologies, echoing the significant emphasis placed on leadership support within traditional technology adoption literature, for cultivating an innovation-friendly environment (Herold et al., 2006; Bass, 1985). However, this support was not limited to endorsement or resource allocation but extended to the creation of a culture suitable for experimentation and quick adaptation—elements increasingly vital in the face of the pandemic's exigencies. Such an approach to leadership support diverges from the static characterizations often found in traditional models, advocating instead for an adaptive, dynamic, and agile leadership style, influenced by the successes and learnings from ongoing implementations and better suited to navigate uncertainty (Bass, 1985; Yunis et al., 2018).

The leadership was willing to drop the rigid frameworks that previously dictated testing dynamics in an industry with stringent regulations, allowing users to try out of the box approaches. By empowering employees and giving space for experimentation, leaders turned the crisis into a catalyst for innovation (Gao & Jiang, 2019; Yuan et al., 2022). We see a move away from traditional, hierarchical models and towards a collective, adaptive approach to technology adoption that leverages the strengths and insights of the entire organization, more aligned with the principles of distributed leadership (Hoch & Kozlowski, 2014).

The leadership was able to create the environment where the adoption decisions would emerge from the best fit, instead of trying to impose a centralized top-down decision making. This leadership style is aligned with open innovation literature, which highlights the critical role of top management support and an open culture in facilitating successful innovation practices (Barham et al., 2020). This form of leadership support goes beyond conventional expectations, actively cultivating an environment where innovation is not just encouraged but is a natural outcome of the organization's adaptive strategies.

5.2.4 Shared Experience

The shared experience of adapting to the new status quo – ushered by the COVID-19 regulations – catalyzed the breakdown of traditional group boundaries across departments and even organizations, fostering a deep sense of communal trust and collective purpose. (Ntontis et al., 2020). Traditional client-provider roles and expectations of individual responsibilities gave way to more solution-seeking, collaborative engagements (Al-Omoush et al., 2020). Interactions were characterized by openness to new ideas, which raised trust and diffusion of information across organizational lines (Liu et al., 2022).

This emerging cohesiveness was not just about facing challenges together but also about forging deeper connections through empathy and patience. While the external environment catalyzed the dissolution of traditional group boundaries, the new collective identity was not merely a matter of compliance with the communal objective, but a deeper sense of internalization and identification sustained by social influence (Graf-Vlachy, et al., 2018)

Tech adoption literature has recognized the value of integrating insights from collaboration research to better understand the adoption process, leading to the study of specific factors such as group characteristics, social influence, and facilitating conditions (Brown et al., 2010). From our research it appears that there is a specific dynamic in place, whereby providing facilitating conditions in times of uncertainty, pre-existing social boundaries can expand, altering group characteristics and potentially increasing the effects of social influence. The enlargement of the social identity had a positive influence in communally overcoming challenges, aligned with research of the effect of social identity in virtual communities (Purohit et al., 2012).

The emergence of a collective and solution-oriented approach signifies a shift towards a more transparent, agile, and adaptive organizational culture. Again, we find a strong parallel to an open innovation approach, where boundaries are more permeable to allow greater flow of information (Chesbrough, 2003).

5.3 Dynamics

Instead of the standard linear progression resulting in employees reaching a determined degree of acceptance towards the technology, our results point towards a dynamic and iterative adoption process. This process was underpinned by a proactive attitude and a sense of collective trust, fueled by leadership support and a culture of rapid experimentation and process adaptation. The characteristics of the process appear to indicate a new type of adoption that is highly aligned with an open innovation approach.

5.3.1 Initiative

Our results show that the push towards new technology adoption came from multiple focal points simultaneously. Leadership initiative was fundamental in pushing for adoption but also in providing support for initiatives to adopt to sprout. We also saw proposals and requests arising across roles, departments, and companies. Furthermore, we saw a similar pattern when it came to adapting processes to new technology or fitting the new available technology towards different problems within the network as well as the opening of new possibilities in terms of coordination and collaboration. The empowerment of individuals across different organizational levels to initiate and drive technology adoption reflects the open innovation ethos of democratizing innovation, where ideas and initiatives can originate from any level within or outside the organization (Ahn et al., 2015).

The findings also highlight the decentralized approach to decision-making taken in the adoption of AR technologies. Leadership support was indeed crucial but not in the directive sense often depicted. Rather, it facilitated an environment of trust from which innovation would spring from the various organizational levels: project managers, IT specialists, and end-users. This mirrors agile and open innovation literature, which sees the people-driven process—with bottom-up participatory feedback—as the necessary condition for adaptive governance (Highsmith, 2009; Chesbrough, 2006).

5.3.2 Technological Tinkering

Technology is mostly treated as a monolith in the traditional tech adoption models, where it is defined prior to the adoption process and understood as fixed in its capabilities or applications. Instead, it is clear in our result that AR technology showed an agnosticism towards a predefined technology, encompassing a variety of hardware, software, configurations, and applications; all of which are in a state of continual evolution. Due to the technology characteristics of AR, it has been shown that there is a need for an approach that considers adaptive configuration (Verbelen et al., 2014).

Initial technological choices were driven mostly by access to the technology. In non-corporate settings access is often dictated by the economic capability of an individual to acquire a technology (Busch, 2011). In traditional corporate adoption, access is a given since the decision to adopt predates implementation. In our research setting, instead of being treated as a precondition to the primary adoption decision, it was weaved into the secondary adoption process through tinkering.

Compatibility at a network level – in terms of software, hardware, physical environment, and abidance to industry regulations – played a central role in determining perceptions of usefulness and ease of use, in line with previous studies (Dubois et al., 2002; Basoglu et al., 2018). The perceived usefulness and ease of use evolved throughout the tinkering process as more users gained access to the technologies and tested them in real-world applications. This dynamic further evidences the limitation of traditional models, who disregard the feedback loops between implementation with the primary and secondary adoption processes.

The agility and flexibility observed in adopting and experimenting with AR technologies are vastly aligned with open innovation's call for dynamic, agile, and iterative approaches in innovation processes, allowing for rapid adaptation to changing circumstances (Bogers et al., 2018). The progression of the technology fit was only secondarily driven by new technological advances. Instead, it was reciprocally influenced by organizational and environmental factors and shaped by the dynamism of a tinkering-based adoption process. The process of adopting AR technologies, as depicted through multi-tech tinkering, reflects a principle of open innovation of integrating external innovations and knowledge with internal development processes to drive technology adoption and organizational change (Wang & Lo, 2016).

Similarly, the organizational processes and structures, initially perceived as fixed, are reshaped by the integration of new technologies, challenging the foundational premises of preexisting processes. The use of AR technologies as platforms for innovation in our study reflects the growing trend in open innovation literature that emphasizes the role of digital platforms and technology in enabling and scaling open innovation processes (Nambisan et al., 2018).

5.3.3 Multi-purpose

Tinkering was not exclusive to technological configurations but also to their applications. The phenomenon of multi-purpose adoption observed in this study underscores a departure from the traditional linear perspective of technology adoption, where employees are seen merely as end-users who either accept or reject new technology (Davis, 1989; Venkatesh & Davis, 2000). While the literature on technology adoption assumes the adoption decision to come first, and then employees displaying a level of acceptance towards the actual usage of the technology, we found acceptance to technology adoption to come first, and the decision to adopt to come only after experimentations towards an array of applications.

The initial intent for the adoption of AR was to replace travel by MNC experts to the CMOs' sites in the later stages of knowledge transfer projects. Towards this purpose, we saw a more structured and formal approach, with the involvement of leadership. Yet, employees actively engaged in the exploration and exploitation of technology beyond its initial scope. Applications included troubleshooting, machine verification and repair, training, and general collaborations. Employees also saw potential applications both internally and externally for many interactions that would benefit from the increased immersion afforded by AR, for processes that would traditionally require PCMs such as audits, quality assurance, brainstorming, and even daily operations. These explorative applications of AR were more informal and iterative, driven by users in the periphery and enabled by support from the leadership and the emergent broader social identity where employees across the sample were united in finding solutions collaboratively.

We saw an increase in the diffusion of information along existing interaction, increased frequency of interaction, and the rise of new exchanges in the network that previously had to be contingent on physical travel. These new interactions became possible thanks to the increased richness of knowledge that could now be transmitted through a TCM, and which also provided additional tacit information, useful towards establishing greater trust (Alsharo et al., 2017).

The emergent, user-driven exploration and application of AR technologies aligns with recent discussions in technology adoption literature emphasizing the importance of user innovation and the iterative integration of technologies into diverse organizational contexts (Rogers, 2016; Wan et al., 2020; Brem & Viardot, 2017). This user-centric approach to technology adoption and adaptation challenges the linear progression of decision-making depicted in models like the (TAM) and expands on the notion of perceived usefulness and ease of use to include user creativity and organizational support as critical factors (Venkatesh et al., 2016).

The active role that the users played in the adoption process is highly aligned with open innovation practices (Curley, 2016). We see a shift towards a more dynamic and participatory form of technology adoption, where the blurring of boundaries between the users and the innovators and decision makers allows for greater organizational learning, leading to a more effective integration of technology (Chesbrough & Bogers, 2014). Moreover, this process of multi-purpose technology adoption underscores the need of a flexible and adaptive approach to AR adoption, where the continuous exploration of potential uses serves to encourage a culture of learning and innovation (Edmondson, 1999). This adaptive and iterative approach could be crucial for organizations aiming to maintain competitiveness and agility in rapidly evolving industries, and even indispensable for survival in the cases of external shocks with disruptive effects.

5.3.4 Collaboration

Our results show an enhancement of collaborative practices, characterized by greater openness, far beyond the norm in an industry characterized by stringent contractual oversight and rigidity around information diffusion to protect IP (Morgan et al., 2018). By openness we mean firstly an increase of network connectivity, both in terms of density - i.e., an increase in the amounts of connections between employees - and in frequency of interactions. Increased network density and frequency of interactions have been shown to facilitate knowledge exchange within collaborative networks and increase innovation performance (Papa et al, 2020; Xie et al, 2016). Diverse network connections encourage the exploration of novel insights, including tacit knowledge, enriching the knowledge sharing process (Wang et al., 2014). Secondly, an enhanced knowledge sharing, characterized by the transmission of more comprehensive information, including tacit knowledge, pertinent spatial information, and real-time interactions. The interactions were underscored by greater transparency, creating an environment more conducive to the free flow of knowledge (Karna & Ko 2015).

The technology characteristics of AR played a significant role in facilitating an unprecedented level of openness in information diffusion. The possibility of transmitting real-time spatial information through a TCM that was previously only accessible through physical presence allowed for quicker and more frequent interactions, as well as new ones, between individuals that would previously not have the possibility of being present on-site. Thus, bypassing bureaucratic and logistical barriers for knowledge sharing (Poretski et al., 2018; Poretski et al., 2021). Similarly, by providing dynamic information in real-time, AR facilitated the transmission of richer information - including tacit knowledge - in a more streamlined and recurrent manner, and to a broader audience than previously possible (Lampropoulos et al., 2020).

The environment also played a fundamental role in increasing the level of openness of interactions. As elaborated in the prior discussion on influencers, the evolving positive and proactive attitudes towards AR adoption - in great part developed thanks to a high situational involvement from the start – cultivated a fertile environment for change (Leso & Cortimiglia, 2022). Furthermore, the shared sense of purpose fostered a culture of trust, further bolstered by substantial leadership support served as a brewing ground for a more proactive, collaborative, and agile adoption process (Nguyen et al., 2023; Al-Omoush et al., 2020; Chatterjee et al., 2022). Within the context of technology adoption, trust – not only in the technology, but also among collaborating entities – is essential for the free flow of information and resources necessary for innovation (Sisodiya et al., 2013).

We observe an exploratory adoption process that was intertwined with the rapid adaptation of existing exploitative processes. This duality highlights how openness was both beneficial towards the adoption of AR, but also emerged as a consequence of the adoption process itself, influenced by technological characteristics, environmental factors, and emerging organizational characteristics. This interweaving of exploration and exploitation reflects a dynamic, non-linear approach to organizational change, challenging traditional models of technology adoption. This evolution from traditional, compartmentalized approaches to a more integrated and collaborative innovation strategy underscores a broader trend within technology adoption literature that recognizes the critical role of cross-functional and inter-organizational collaboration in leveraging diverse knowledge and resources for innovation (Granstrand & Holgersson, 2020).

The dissolution of group identity dictated by roles and departments towards a more cohesive sense of togetherness manifested in the collaborations across the partner network, aligned with the emphasis laid by open innovation on collaborative efforts that transcend organizational boundaries. The increase in network connectivity and information diffusion found are a hallmark of open innovation, where cross-collaborations are deemed crucial to leverage diverse knowledge and resources throughout the network to innovate (Chesbrough et al., 2018).

5.4 Towards an Open Adoption model

This study has evidenced that seminal frameworks such as the Diffusion of Innovations (DOI), Technology-Organization-Environment (TOE), Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT) fall short in capturing the nuanced and dynamic nature of technology adoption in contemporary organizational contexts, particularly under conditions that demand agile adaptability. The findings underscore three critical limitations inherent in these models:

1) **Linear Process**: Contrary to the linear progression assumed by traditional models, the adoption of AR technologies in this study was characterized by a dynamic and iterative process. This process took place through cycles, both through explorative tinkering and the continuous adaptation of pre-existing processes to maximize the exploitation of AR's capabilities. The empirical evidence calls for the development of new frameworks that conceptualize adoption as iterative and dynamic (Clark et al., 2019).

2) **Top-Down and Rigid Decision-Making**: Instead of a centralized top-down adoption decision, bottom-up initiative and feedback played a critical role in the process. The results indicate that a more distributed leadership approach, focused on empowering employees and creating a culture of innovation, facilitated a more inclusive and informed approach to decision making. Future adoption models need to recognize the interaction between leadership decisions and user feedback (Röcker, 2010). Whilst managers should advocate for greater agility and adaptiveness in the governance processes of technology adoption (Janssen & Van der Voort, 2020).

3) **Interplay with Organizational Processes**: The integration of AR technologies within organizational practices has unveiled a profound interplay between technology adoption and organizational change. The study illustrates that successful adoption extends beyond user acceptance, necessitating adjustments in workflows, roles, and organizational culture. This finding urges the consideration of frameworks that account for the continuous interaction between technology integration, organizational evolution, and employee attitude. (Frambach & Schillewaert, 2002; Ifenthaler & Egloffstein, 2020).

Building on the critical insights derived from our study, it becomes evident that the adoption of AR technologies within the context of crisis-induced regulations unveils a new type of technology adoption process. This process is highly congruent with open innovation practices and could be thought of as 'open technology adoption'. The studied technology adoption process diverges significantly from the traditional paradigms captured by seminal models such as DOI, TOE, TAM, and UTAUT, instead it is based on an open approach with the core properties of Decentralization, Iteration, and Adaptability (DIA).

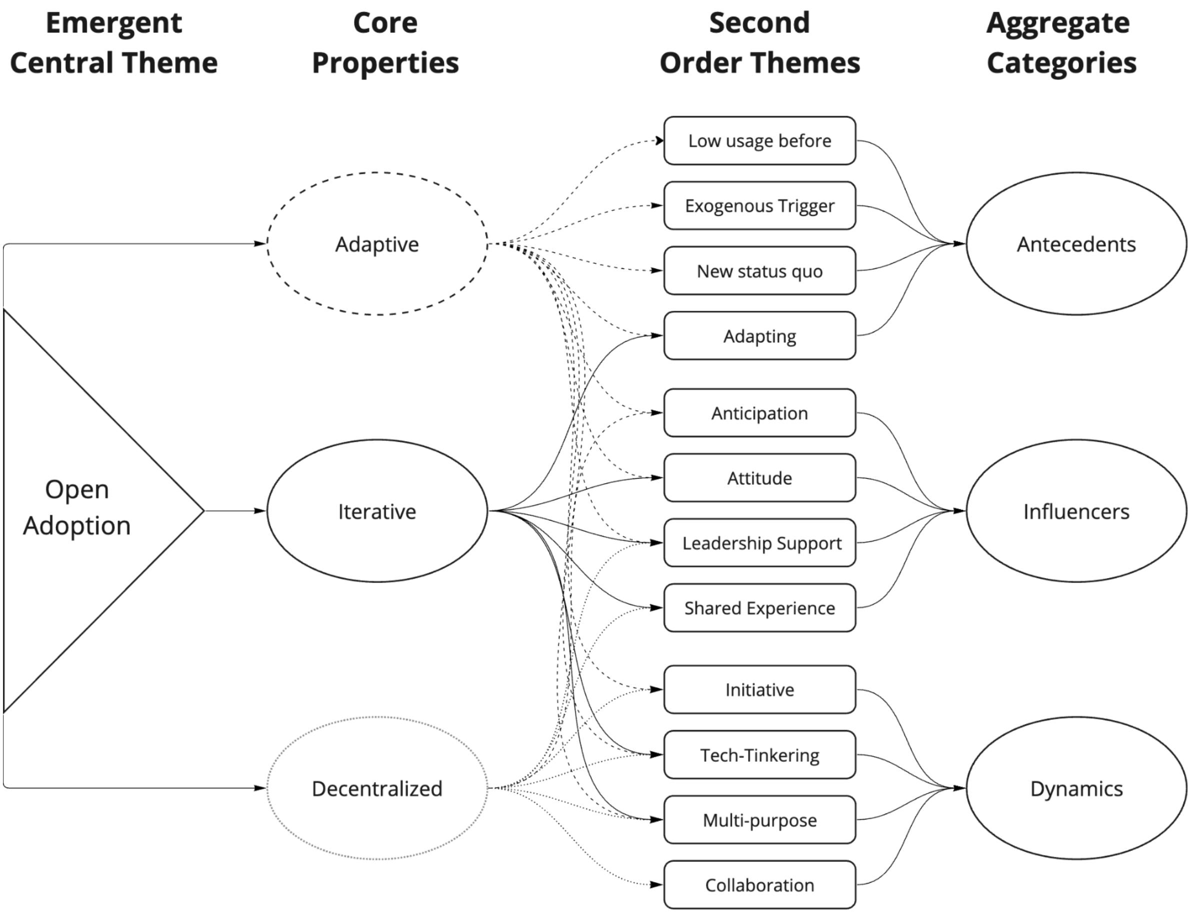

Figure 4: DIA model of Open Adoption (Own representation)

Figure 4 presents the central theme *Open Adoption* that emerged from the codes after the reputed axial codes - developed in phase 3 of our analysis of data - were contrasted with technology adoption and acceptance literature, leading to the identification of limitations of traditional adoption models. In phase 4, selective coding was conducted, drawing connections to the central theme from the second order themes that had been refined in phase 3. The connections follow a logic of dimensions (labels), rather than siloed categories.

1) **Decentralized**: Contrary to the hierarchical and centralized decision-making processes emphasized in traditional models, our findings highlight a process where employees across the sample were aware and involved from the very beginning, even before trials took place, they *anticipated* the changes to come. *Initiative* and *collaboration* were present across the organizational spectrum. These dynamics were underscored by distributed *leadership* and the perception of a *shared experience*, which increased user involvement and transformed the adoption of AR technology into a collective journey. The *technology* itself was not treated as a monolithic entity but as a multifaceted network, through the evaluation of multiple software and hardware. Similarly, we found that a myriad of potential *purposes* were tested, affecting multiple existing processes and opening the possibility of new process generation. This decentralized approach facilitated greater exploration, transparency, information diffusion, and connectivity within and across organizational boundaries.

2) **Iterative**: Our study reveals a distinctly iterative process, intertwining primary and secondary adoption phases with the actual implementation. This process is characterized by continuous feedback loops among key factors such as *anticipation*, *leadership support*, organizational culture, trust,

attitude, and group cohesion elicited through a perception of a *shared experience*. The evaluation of AR was not conducted by leadership prior to the secondary adoption, but rather through an iterative *tinkering* process, where multiple *technologies* – both software and hardware – were tested towards *multiple purposes* and processes in order to optimize configurations, compatibility, and tech-task fit. Such feedback mechanisms underscore the need for adoption models to account for the dynamic interplay between technology usage, organizational needs, and the evolution of processes.

3) **Adaptive**: The adoption process we observed was primarily driven by a need to *adapt* rapidly to the *new status quo* brought about by an *exogenous trigger*; which in our case were the COVID-19 regulations. The disposition to adapt was present from the beginning, where employees started to *anticipate* the changes to come thanks to their high situational involvement. This adaptive *attitude* persisted through the testing and implementation of AR, both in relation to the adoption of AR, but also in regard to the organizational processes and interpersonal relationships. Employees were active participants in the process, driving initiatives to adapt previous processes to the new limitations and emerging needs. Leadership was willing to depart from predetermined approaches and adapt to the evolving circumstances and support adaptive strategies of tinkering around the technologies and potential purposes. These strategies ushered greater organizational agility and resilience.

For its acronym we propose to refer to this type of technology adoption as *DIA*. This new understanding not only challenges the foundational premises of traditional models but also opens avenues for developing more comprehensive and applicable frameworks that can more accurately reflect the nuanced realities of technology adoption in today's evolving environments, especially in the face of exogenous forces that demand rapid adaptation and flexibility. Similarly, it requires management to put behind outdated process management approaches and embrace greater openness and agility.

6. CONCLUSION

6.1 Key Findings

The key insight of this study is that traditional adoption models are inadequate frameworks to comprehensively understand the dynamics observed in the adoption of AR technologies within the pharmaceutical industry during the COVID-19 pandemic. The premises of linear progression, top-down decision-making, and a segmented view of organizational processes point researchers in the wrong direction, creating research hypotheses that are based on evaluating factors of adoption as fixed preconditions to adoption. Recent studies on technology adoption have also highlighted the shortcomings of applying traditional models to innovative technologies (Dube et al., 2020; Sobhanmanesh et al., 2023).

In line with adoption literature, we found that factors such as leadership support, trust, and attitude, to be fundamental towards a successful adoption process (Roberts & Flin, 2020). Yet, these factors evolved throughout the adoption process as employees gained exposure to actual usage of the technology; this finding is aligned with recent empirical research on AR adoption in manufacturing (Aquino et al., 2023). Access to technology served as a springboard to dynamize organizational processes beyond the initially conceptualized purpose of the technology. Showing that also task-tech fit is an evolving factor, which can be strengthened through iterations (Rai & Selnes, 2019). Furthermore, these factors influence each other, potentially creating feedback loops that can be essential for the successful adoption of the technology (Tsiknakis & Kouroubali, 2009).

Additionally, we found the presence of new factors that have not been fully addressed by the literature: anticipation and cohesion. Anticipation seems to be related to attitude, but rather than simply meaning the attitude an individual has towards a particular behavior – in our concept towards adopting a new tech – it touches on an individuals' capacity to be prepared for the oncoming process and develop proactive attitudes towards it. While attitude is reflective of the past experiences an individual has had, leading to a defined attitude at the time of being in the position to implement a new technology, anticipation is forward looking and proactive. We believe anticipation played such an important role thanks to a high situational involvement; adapting to future needs and challenges can be crucial for successful technology integration (Janboecke & Zajitschek, 2021).

Cohesion was paramount towards enabling the open collaboration dynamics in the process. Fueled by a sense of shared identity in response to the new status quo, employees across the different companies in the sample expanded their group identity towards a collective value oriented approach. A sense of common faith produced an emerging shared social identity that has been shown to foster collective self-organization in emergencies (Drury, 2018). While previous literature has dealt with group characteristics and other related factors, it seems to have failed at pinpointing the importance of the development of a cohesive group identity for a successful adoption process. Research has shown that group cohesiveness significantly affects team satisfaction and performance, supporting the argument that the development of a cohesive group identity is vital for successful technology adoption, especially in innovative contexts (Bravo et al., 2019; Grossman et al., 2022; Hassandoust & Techatassanasoontorn, 2022).

The characteristics of the technology allowed for greater connectivity in the network and diffusion of information, validating AR as a TCM that improves knowledge flows and the exchange of tacit information. We saw an increase in network connections, in frequency of virtual interactions, and in the richness of information that could be shared through virtual means. These tangible benefits to knowledge sharing permeated both the adoption and the organizational processes. Furthermore, showing the disruptive capacity of AR towards not only sustaining interactions that previously relied on physical presence, but in enabling process optimization and organizational transformation.

We arrive at a definition of a new type of adoption which is characterized by decentralization, iteration, and adaptability. We find a decentralized approach in the sprawling initiatives to adopt, in collaborations towards process improvements, in the approach taken towards the technology components, and in the explorative and exploitative strategies towards making the best use of the technology. Iteration became habitual as the organizations tried to achieve the best fit between technology and processes, also found in the manners that key factors such as leadership support, trust, culture, and attitude influenced each other throughout the process. Adaptability is paramount in order to sustain operations in times of crisis (Łukasik & A. Porębska, 2022). Our study evidenced that adaptability was present from the beginning, as the key logic driving the whole process was to adapt to a new status quo ushered in by COVID-19 regulations. Beyond its initial role in triggering adoption, adaptability ended up underscoring the whole adoption process, as the culture, the leadership approach, the attitudes towards the technology as well as the actual adoption and implementation adapted to respond to urgent requirements and to relevant process improvements. There appears to be a paradigm shift towards more adaptable and flexible approaches to knowledge sharing (Weitzel et al., 2021).

These properties appear aligned with open innovation theory, suggesting both a theoretical bridge between the literatures, and a practical definition that could serve leaders and organizations towards ushering in the application of more agile management frameworks when adopting new technologies. The DIA model of open adoption is a working framework that better serves the reality of rapid technology adoption as a response to a crisis. The empirical evidence gathered showcases a process fueled by anticipatory behaviors, a developing culture of open collaboration, and a leadership style that empowers and fosters experimentation, directly contesting the linear and rigid models traditionally espoused (Clark et al., 2019; Janssen & Van der Voort, 2020; Frambach & Schillewaert, 2002).

6.2 Limitations and Further Research

Although the current study has a considerably large sample size for a grounded theory approach (N=22), the majority of the sample consists of project managers and technology experts. Further studies with greater presence of technical operators who are lower in the hierarchical structure would enrich the findings. Furthermore, certain individuals in the sample – particularly technology experts – could hold pro-innovation bias that could skew results. Pro-innovation bias was defined by Rogers (2003) as the belief that innovation should be rapidly adopted without a need to modify its original format. This effect might be exacerbated by company efforts to train and motivate users to accept the technology. There could also be a pro-innovation bias due to the purposeful sampling logic, where interviewees might not have agreed to participate in the study if they held negative opinions about the adoption process or the organization, leading to a sampling bias where those who agreed have a preexisting positive opinion towards the adoption process (Saunders et al., 2016). Additionally, our sample is restricted to individuals that live in western societies: Germany, Norway, Switzerland, France, Italy, and the USA. Additional studies with a broader cultural sample could shed light into the effects of culture on the acceptance of remote assistance technologies, as well as take into account potential adoption barriers derived from language differences.

The study took place in the piloting stage of the technology. Earlier studies have suggested that pre-implementation expectations might be poor indicators of adoption success (Ginzberg, 1980); although this has been later contested (Davis & Venkatesh, 2004). In any case, longitudinal studies that follow the adoption process before the technology has been introduced to the organizations, and which considers the reality post-implementation of the technology would increase the robustness of results.

The grounded theory approach taken in this study allowed for a holistic view of the myriad of factors and dynamics that unfolded throughout the adoption process. Coupled with a clean slate perspective, it helped to uncover key limitations in the technology adoption process and greater specificity of the ongoing interactions. Yet, this resulted in a broadening of the scope which created inefficiencies in exploring in depth all of the insights. Further qualitative studies are needed, which do not take a grounded theory approach, but rather have a more specific focus from the beginning, with regards to exploring key feedback loops between attitude and leadership support, trust and voluntariness of use, and task-tech fit and actual usage.

Quantitative studies with clear hypotheses are necessary to validate the qualitative evidence of the effects of key factors in the adoption process. The complexity of the relationships between factors should not be an excuse to fall into absolute relativism. Instead, acknowledging the feedback loops of key adoption factors should warrant the implementation of large scale studies that consider multiple organizations with different initial statuses, organizational cultures, and approaches to tech adoption that could bring greater clarity in assessing the causality of adoption factors as they evolve through the process.

Finally, there is uncertainty about the generalizability of our findings. From the scope of our research, it is unclear to what extent the dynamism of the process is due to environment, which brought forth a need to rapidly adapt to an exogenous force, the technology, which by its nature increased the diffusion of information and served to improve multiple processes, or the organization, which fostered a culture of trust and experimentation. Further research is needed which controls for the evolving nature of all three of the TOE components or alternatively meta-studies which contrast adoption processes of different technologies, organizations, and environments.

6.4 Managerial Implications

Towards the adoption of disruptive communication technologies such as AR, organizations would benefit from reassessing top-down decision making, linear adoption, and fixed technology, organization, and environment components. Instead, there is another path: one of embracing an open innovation approach by leveraging the knowledge of partner networks and empowering individuals at different organizational levels (Chesbrough, 2003; Ahn et al., 2015), as well as providing leadership support and a culture that embraces experimentation and risk-taking (Barham et al., 2020).

Our research highlights the need for organizations to adopt more agile approaches to technology adoption, moving away from traditional project management paradigms. AR technologies have the potential to alter many organizational processes and even impact the culture and the relationship within an organization and its partner network. Our recommendation is for managers to let go of rigidity and embrace entering the adoption process as an exploration. Agile methodologies can provide useful heuristics to maximize the communication and collaboration throughout the adoption process, managers should foster interaction across functions and departments fostering a sense of shared responsibility and ownership for the adoption process (Hidalgo, 2019). By ensuring that the users of the technology are involved early, an organization can increase intrinsic involvement and ensure that there are progressive improvements based on actual usage that are better aligned with existing processes (Leso & Cortimiglia, 2022; Hassandoust & Techatassanasoontorn, 2022). This can also allow for multiple learning cycles which could also serve towards process optimization and ensure a value-driven approach that can deliver value early and continuously (Serrador & Pinto, 2015; Madhuri & Goteti, 2018). Beyond providing leadership support, organizations also would benefit from embracing a decentralized and adaptive approach to the integration and utilization of AR technologies, making decisions based on user feedback and observed results (Hasgall & Ahituv, 2018).

The proposed Decentralized, Iterative, and Adaptative (DIA) Adoption Model, is not a rigid structure for the evaluation of dynamic adoption processes, but rather a descriptive framework of the processes, similar to the understanding of open innovation as a model. Its acronym *DIA* means *day* in Spanish, this is a call to organizational leaders, technology experts, and managers to take the adoption process one day at a time. In order for managers to create the conditions of a DIA adoption, we propose that they consider the Antecedents, Influencers and Dynamics (AID). As antecedents to an open adoption approach, organizations should consider the current access and use of technology as well as potential triggers for an adoption process and the evolution of the status quo at an industry level. Fundamentally, they must put forth a vision that is aligned with an adaptive frame. Secondly, they should embrace how key factors such as culture, trust, leadership support, and attitude will continuously influence each other throughout the process, engaging in their malleability and creating positive feedback loops. Finally, they should welcome open innovation dynamics, putting forth agile methodologies to introduce implementation early on and improve iteratively, increase diffusion of information and collaboration throughout its network, and be willing to adapt throughout the process.

7. REFERENCES

Ahn, J. M., Minshall, T., & Mortara, L. (2015). Open innovation: a new classification and its impact on firm performance in innovative SMEs. Journal of Innovation Management, 3(2), p33-54.

Akçayır, M., Akçayır, G., Pektaş, H. M., & Ocak, M. A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. Computers in Human Behavior, 57, 334-342.

Al-Omoush, K. S., Simón-Moya, V., & Sendra-García, J. (2020). The impact of social capital and collaborative knowledge creation on e-business proactiveness and organizational agility in responding to the COVID-19 crisis. Journal of Innovation & Knowledge, 5(4), 279-288.

Almeida, F., Santos, J. D., & Monteiro, J. A. (2020). The challenges and opportunities in the digitalization of companies in a post-COVID-19 World. IEEE Engineering Management Review, 48(3), 97-103.

Alsharo, M., Gregg, D., & Ramirez, R. (2017). Virtual team effectiveness: The role of knowledge sharing and trust. Information and Management, 54(4), 479–490.

Alvesson, M., and Ashcraft, K.L. (2012): "Interviews" in Symon, G. and Cassell, C. (eds.) The Practice of Qualitative Organizational Research: Core Methods and Current Challenges, London, Sage, pp 239–257.

Ambrosini, V., & Bowman, C. (2001). Tacit knowledge: Some suggestions for operationalization. Journal of Management Studies, 38(6), 811–829.

Aquino, S., Rapaccini, M., Adrodegari, F., & Pezzotta, G. (2023). Augmented reality for industrial services provision: the factors influencing a successful adoption in manufacturing companies. Journal of Manufacturing Technology Management, 34(4), 601-620

Argote, L., & Miron-Spektor, E. (2011). Organizational learning: From experience to knowledge. Organization science, 22(5), 1123-1137.

Ayati, N., Saiyarsarai, P., & Nikfar, S. (2020). Short and long term impacts of COVID-19 on the pharmaceutical sector. DARU Journal of Pharmaceutical Sciences, 28, 799-805.

Azuma, R. T. (1997). A survey of augmented reality. Presence: teleoperators & virtual environments, 6(4), 355-385.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. IEEE computer graphics and applications, 21(6), 34-47.

Baaren, E., Van de Wijngaert, L., & Huizer, E. (2011). Understanding technology adoption through individual and context characteristics: The case of HDTV. Journal of Broadcasting & Electronic Media, 55(1), 72-89.

Bailey, J. E., & Pearson, S. W. (1983). Development of a tool for measuring and analyzing computer user satisfaction. Management science, 29(5), 530-545.

Baldassi, S., Kohno, T., Roesner, F., & Tian, M. (2018). Challenges and new directions in augmented reality, computer security, and neuroscience--part 1: Risks to sensation and perception. arXiv preprint arXiv:1806.10557.

Barham, H., Dabic, M., Daim, T., & Shifrer, D. (2020). The role of management support for the implementation of open innovation practices in firms. Technology in Society, 63, 101282.

Basoglu, N. A., Goken, M., Dabic, M., Ozdemir Gungor, D., & Daim, T. U. (2018). Exploring adoption of augmented reality smart glasses: Applications in the medical industry.

Bass, B. M. (1985). Leadership: Good, better, best. Organizational dynamics, 13(3), 26-40.

Battistella, C. (2014). The organisation of Corporate Foresight: A multiple case study in the telecommunication industry. Technological Forecasting and Social Change, 87, 60-79.

Bayerl, P. S., Lauche, K., & Axtell, C. (2016). Revisiting group-based technology adoption as a dynamic process. Mis Quarterly, 40(3), 775-784.

Beaudry, A., & Pinsonneault, A. (2010). The other side of acceptance: Studying the direct and indirect effects of emotions on information technology use. MIS quarterly, 689-710.

Bignami, F., Mattsson, P., & Hoekman, J. (2020). The importance of geographical distance to different types of R&D collaboration in the pharmaceutical industry. Industry and Innovation, 27(5), 513-537.

Billinghurst, M., Kato, H., & Poupyrev, I. (2001). The magicbook-moving seamlessly between reality and virtuality. IEEE Computer Graphics and applications, 21(3), 6-8.

Bogers, M., Chesbrough, H., & Moedas, C. (2018). Open innovation: Research, practices, and policies. California management review, 60(2), 5-16.

Boswell, J., Corbett, J., Rhodes, R. A. W., & Salomonsen, H. H. (2021). The comparative 'court politics' of Covid-19: Explaining government responses to the pandemic. Journal of European Public Policy, 28(8), 1258-1277.

Bottani, E., & Vignali, G. (2019). Augmented reality technology in the manufacturing industry: A review of the last decade. IISE Transactions, 51(3), 284– 310.

Bower, M., Lee, M. J., & Dalgarno, B. (2017). Collaborative learning across physical and virtual worlds: Factors supporting and constraining learners in a blended reality environment. British Journal of Educational Technology, 48(2), 407-430.

Bravo, R., Catalán, S., & Pina, J. M. (2019). Analysing teamwork in higher education: An empirical study on the antecedents and consequences of team cohesiveness. Studies in Higher Education, 44(7), 1153-1165.

Brem, A., Viardot, E., & Nylund, P. A. (2021). Implications of the coronavirus (COVID-19) outbreak for innovation: Which technologies will improve our lives?. Technological forecasting and social change, 163, 120451.

Brem, A., & Viardot, E. (2017). Revolution of innovation management: The digital breakthrough (pp. 1-16). Palgrave Macmillan UK.

Brock, K., den Ouden, E., Langerak, F., & Podoynitsyna, K. (2020). Front End Transfers of Digital Innovations in a Hybrid Agile-Stage-Gate Setting. Journal of Product Innovation Management, 37(6), 506–527.

Brown, W. J., & Basil, M. D. (2010). Parasocial interaction and identification: Social change processes for effective health interventions. Health communication, 25(6-7), 601-602.

Busch, T. (2011). Capabilities in, capabilities out: overcoming digital divides by promoting corporate citizenship and fair ICT. Ethics and Information Technology, 13(4), 339-353.

Martín-de Castro, G. (2015). Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. Industrial marketing management, 47, 143-146.

Cepeda-Carrion, G., Cegarra-Navarro, J. G., & Jimenez-Jimenez, D. (2012). The effect of absorptive capacity on innovativeness: Context and information systems capability as catalysts. British Journal of Management, 23(1), 110-129.

Chatterjee, S., Chaudhuri, R., & Vrontis, D. (2022). Examining the impact of adoption of emerging technology and supply chain resilience on firm performance: moderating role of absorptive capacity and leadership support. IEEE Transactions on Engineering Management.

Chesbrough, H. W. (2003). Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press.

Chesbrough, H. (2006). Open business models: How to thrive in the new innovation landscape. Harvard Business Press.

Chesbrough, H., Lettl, C., & Ritter, T. (2018). Value creation and value capture in open innovation. Journal of Product Innovation Management, 35(6), 930-938.

Chesbrough, H., & Bogers, M. (2014). Explicating open innovation: Clarifying an emerging paradigm for understanding innovation. New Frontiers in Open Innovation. Oxford: Oxford University Press, Forthcoming, 3-28.

Christensen, C. M., Raynor, M., & McDonald, R. (2015). 17. Disruptive Innovation. Harvard Business Review, 93(12), 44-53.

Clark, D., Dean, G., Bolton, S., & Beeson, B. (2020). Bench to bedside: the technology adoption pathway in healthcare. Health and Technology, 10, 537-545.

Coccia, M. (2023). Sources, diffusion and prediction in COVID-19 pandemic: lessons learned to face next health emergency. AIMS Public Health, 10(1), 145.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. Qualitative Sociology, 13(1), 3–21.

Cummings, J. L., & Teng, B. S. (2003). Transferring R&D knowledge: the key factors affecting knowledge transfer success. Journal of Engineering and technology management, 20(1-2), 39-68.

Curley, M. (2016). Twelve principles for open innovation 2.0. Nature, 533(7603), 314-316.

Dahabiyeh, L., Najjar, M. S., & Agrawal, D. (2020). The effect of risk levels on technology adoption decision: the case of online games. Information Technology & People, 33(5), 1445-1464.

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results (Doctoral dissertation, Massachusetts Institute of Technology).

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. Management science, 35(8), 982-1003.

Davis, F. D., & Venkatesh, V. (2004). Toward preprototype user acceptance testing of new information systems: implications for software project management. IEEE Transactions on Engineering management, 51(1), 31-46.

de Vries, J., Schepers, J., van Weele, A., & van der Valk, W. (2014). When do they care to share? How manufacturers make contracted service partners share knowledge. Industrial Marketing Management, 43(7), 1225-1235.

Diffenbaugh, N. S., & Field, C. B. (2013). Changes in ecologically critical terrestrial climate conditions. Science, 341(6145), 486-492.

Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task–technology fit constructs. Information & management, 36(1), 9-21.

Drury, J. (2018). The role of social identity processes in mass emergency behaviour: An integrative review. European review of social psychology, 29(1), 38-81.

Dube, T., Van Eck, R., & Zuva, T. (2020). Review of technology adoption models and theories to measure readiness and acceptable use of technology in a business organization. Journal of Information Technology and Digital World, 2(4), 207-212.

Dubois, E., Nigay, L., & Troccaz, J. (2002). Assessing continuity and compatibility in augmented reality systems. Universal Access in the Information Society, 1, 263-273.

Dwivedi, Y. K., Rana, N. P., Jeyaraj, A., Clement, M., & Williams, M. D. (2019). Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model. Information systems frontiers, 21, 719-734.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. Administrative science quarterly, 44(2), 350-383.

Frambach, R. T., & Schillewaert, N. (2002). Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research. Journal of business research, 55(2), 163-176.

Gao, A., & Jiang, J. (2019). Perceived empowering leadership, harmonious passion, and employee voice: the moderating role of job autonomy. Frontiers in psychology, 10, 456028.

Gefen, D. (2004). What makes an ERP implementation relationship worthwhile: Linking trust mechanisms and ERP usefulness. Journal of Management Information Systems, 21(1), 263-288.

Gefen, D., Karahanna, E., & Straub, D. W. (2003). Trust and TAM in online shopping: An integrated model. MIS quarterly, 51-90.

Ginzberg, M. J. (1980). An organizational contingencies view of accounting and information systems implementation. Accounting, Organizations and Society, 5(4), 369-382.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research:

Notes on the Gioia Methodology. Organizational Research Methods, 16(1), 15–31.

Glaser, B. G., & Strauss, A. L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. Aldine Transaction.

Graf-Vlachy, L., Buhtz, K., & König, A. (2018). Social influence in technology adoption: taking stock and moving forward. Management Review Quarterly, 68, 37-76.

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. Technovation, 90, 102098.

Grossman, R., Nolan, K., Rosch, Z., Mazer, D., & Salas, E. (2022). The team cohesion-performance relationship: A meta-analysis exploring measurement approaches and the changing team landscape. Organizational Psychology Review, 12(2), 181-238.

Hasgall, A., & Ahituv, N. (2018). Implementing continuous adaptation to technology innovation in complex adaptive organizations. The Journal of High Technology Management Research, 29(1), 35-45.

Hassandoust, F., & Techatassanasoontorn, A. A. (2022). Antecedents of IS infusion behaviours: an integrated IT identity and empowerment perspective. Behaviour & Information Technology, 41(11), 2390-2414.

Herold, D. M., Jayaraman, N., & Narayanaswamy, C. R. (2006). What is the relationship between organizational slack and innovation?. Journal of Managerial Issues, 372-392.

Hidalgo, E. S. (2019). Adapting the scrum framework for agile project management in science: case study of a distributed research initiative. Heliyon, 5(3).

Highsmith, J. (2009). Agile project management: creating innovative products. Pearson education.

Hoch, J. E., & Kozlowski, S. W. (2014). Leading virtual teams: Hierarchical leadership, structural supports, and shared team leadership. Journal of applied psychology, 99(3), 390.

Horton, R. P., Buck, T., Waterson, P. E., & Clegg, C. W. (2001). Explaining intranet use with the technology acceptance model. Journal of information technology, 16, 237-249.

Hsiao, C. H., & Yang, C. (2011). The intellectual development of the technology acceptance model: A co-citation analysis. International Journal of Information Management, 31(2), 128-136.

Ifenthaler, D., & Egloffstein, M. (2020). Development and implementation of a maturity model of digital transformation. TechTrends, 64(2), 302-309.

Jackson, C. M., Chow, S., & Leitch, R. A. (1997). Toward an understanding of the behavioral intention to use an information system. Decision sciences, 28(2), 357-389.

Janböcke, S., & Zajitschek, S. (2021). Anticipation Next: System-Sensitive Technology Development and Integration in Work Contexts. Information, 12(7), 269.

Janssen, M., & Van der Voort, H. (2020). Agile and adaptive governance in crisis response: Lessons from the COVID-19 pandemic. International journal of information management, 55, 102180.

Jordan, A., Wurzel, R. K., & Zito, A. R. (2013). Still the century of 'new'environmental policy instruments? Exploring patterns of innovation and continuity. Environmental Politics, 22(1), 155-173

Karahanna, E., Straub, D. W., & Chervany, N. L. (1999). Information technology adoption across time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. MIS quarterly, 183-213.

Karna, D., & Ko, I. (2015, January). We-intention, moral trust, and self-motivation on accelerating knowledge sharing in social collaboration. In 2015 48th Hawaii International Conference on System Sciences (pp. 264-273). IEEE.

Kenealy, G. J. (2012). Grounded theory: A theory building approach. Qualitative organizational research, 1, 408-425.

King, N. (2004) Using Templates in Thematic Analysis of Text. In: Essential Guide to Qualitative Methods in Organizational Research, Sage Publications, London, 257-270.

King, W. R., & He, J. (2006). A meta-analysis of the technology acceptance model. Information & management, 43(6), 740-755.

Klopfer, E., & Squire, K. (2008). Environmental Detectives—the development of an augmented reality platform for environmental simulations. Educational technology research and development, 56, 203-228.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. Organization science, 3(3), 383-397.

Kudyba, S. (2020). COVID-19 and the Acceleration of Digital Transformation and the Future of Work. Information Systems Management, 37(4), 284-287.

Kung, L., & Kung, H. J. (2015). External environment pressure on organizational innovation adoption: From literature to a conceptual model. International Journal of Management Theory and Practice, 15(1), 99-115.

Lampropoulos, G., Keramopoulos, E., & Diamantaras, K. (2020). Enhancing the functionality of augmented reality using deep learning, semantic web and knowledge graphs: A review. Visual Informatics, 4(1), 32-42.

Law, C. C., & Ngai, E. W. (2008). An empirical study of the effects of knowledge sharing and learning behaviors on firm performance. Expert systems with applications, 34(4), 2342-2349.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. Information & management, 40(3), 191-204.

Lehrbaum, Valeriya, Asa MacWilliams, Joseph Newman, Nischita Sudharsan, Seongjin Bien, Konstantin Karas, Chloe Eghtebas, Sandro Weber, and Gudrun Klinker. "Enabling customizable workflows for industrial AR applications" In 2022 IEEE International Symposium on Mixed and Augmented Reality (ISMAR), pp. 622-630. IEEE, 2022.

Leonardi, P. M. (2011). When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies. MIS quarterly, 147-167.

Leso, B. H., & Cortimiglia, M. N. (2022). The influence of user involvement in information system adoption: an extension of TAM. Cognition, Technology & Work, 24(2), 215-231.

Liu, Z., Shi, Y., & Yang, B. (2022). Open innovation in times of crisis: An overview of the healthcare sector in response to the COVID-19 Pandemic. Journal of Open Innovation: Technology, Market, and Complexity, 8(1), 21.

Loupes, P., & Gryegiel, A. (2003). Collaborating across the extended pharmaceutical enterprise: How shoring information leads to process enablement. Biopharm international, 16(6), 34-38.

Łukasik, M., & Porębska, A. (2022). Responsiveness and adaptability of healthcare facilities in emergency scenarios: COVID-19 experience. International Journal of Environmental Research and Public Health, 19(2), 675.

Madhuri, G. V., & Goteti, L. P. (2018, November). Adopting agile values in engineering education. In 2018 IEEE 6th International Conference on MOOCs, Innovation and Technology in Education (MITE) (pp. 103-106). IEEE.

Martins, C., Oliveira, T., & Popovič, A. (2014). Understanding the Internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application. International journal of information management, 34(1), 1-13.

Masson-Delmotte, V. P., Zhai, P., Pirani, S. L., Connors, C., Péan, S., Berger, N., ... & Scheel Monteiro, P. M. (2021). Ipcc, 2021: Summary for policymakers. in: Climate change 2021: The physical science basis. Contribution of working group i to the sixth assessment report of the intergovernmental panel on climate change.

Mathrani, S., & Edwards, B. (2020). Knowledge-sharing strategies in distributed collaborative product development. Journal of Open Innovation: Technology, Market, and Complexity, 6(4), 194.

Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. IEICE TRANSACTIONS on Information and Systems, 77(12), 1321-1329.

Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a World-Wide-Web context. Information & management, 38(4), 217-230.

Morens, D. M., Breman, J. G., Calisher, C. H., Doherty, P. C., Hahn, B. H., Keusch, G. T., ... & Taubenberger, J. K. (2020). The origin of COVID-19 and why it matters. The American journal of tropical medicine and hygiene, 103(3), 955.

Morgan, R., Doran, D., & Morgan, S. J. (2018). Strong contracts: the relationship between power and action. International Journal of Operations and Production Management, 38(1), 272–294.

Mukherjee, A., & Stern, S. (2009). Disclosure or secrecy? The dynamics of open science. International Journal of Industrial Organization, 27(3), 449-462.

Müller, M., Stegelmeyer, D., & Mishra, R. (2023). Development of an augmented reality remote maintenance adoption model through qualitative analysis of success factors. Operations Management Research, 16(3), 1490-1519.

Nambisan, S., Siegel, D., & Kenney, M. (2018). On open innovation, platforms, and entrepreneurship. Strategic Entrepreneurship Journal, 12(3), 354-368.

Nguyen, M., Rundle-Thiele, S., Malik, A., & Budhwar, P. (2023). Impact of technology-based knowledge sharing on employee outcomes: moderation effects of training, support and leadership.

Journal of Knowledge Management, 27(8), 2283-2301.

Nisar, A., Ruiz, F., & Palacios, M. (2013). Organisational learning, strategic rigidity and technology adoption: Implications for electric utilities and renewable energy firms. Renewable and Sustainable Energy Reviews, 22, 438-445.

Nonaka, I., & Takeuchi, H. (1995). The Knowledge-Creating Company. Oxford University Press.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2020). Endurance or decline of emergent groups following a flood disaster: Implications for community resilience. International Journal of Disaster Risk Reduction, 45, 101493.

Obrenovic, B., Du, J., Godinic, D., Tsoy, D., Khan, M. A. S., & Jakhongirov, I. (2020). Sustaining enterprise operations and productivity during the COVID-19 pandemic:"Enterprise Effectiveness and Sustainability Model". Sustainability, 12(15), 5981.

Oh, S., Ahn, J., & Kim, B. (2003). Adoption of broadband Internet in Korea: the role of experience in building attitudes. Journal of Information Technology, 18(4), 267-280.

Papa, A., Chierici, R., Ballestra, L. V., Meissner, D., & Orhan, M. A. (2020). Harvesting reflective knowledge exchange for inbound open innovation in complex collaborative networks: an empirical verification in Europe. Journal of Knowledge Management, 25(4), 669-692.

Parker, S. K., Williams, H. M., & Turner, N. (2006). Modeling the antecedents of proactive behavior at work. Journal of applied psychology, 91(3), 636.

Pavlou, P. A. (2003). Consumer acceptance of electronic commerce: Integrating trust and risk with the technology acceptance model. International journal of electronic commerce, 7(3), 101-134.

Peng, J., Chen, X., Zou, Y., & Nie, Q. (2021). Environmentally specific transformational leadership and team pro-environmental behaviors: The roles of pro-environmental goal clarity, pro-environmental harmonious passion, and power distance. Human Relations, 74(11), 1864-1888.

Pierce, J. L., Kostova, T., & Dirks, K. T. (2003). The state of psychological ownership: Integrating and extending a century of research. Review of general psychology, 7(1), 84-107

Pierri, N., & Timmer, Y. (2022). The importance of technology in banking during a crisis. Journal of Monetary Economics, 128, 88-104.

Plouffe, C. R., Hulland, J. S., & Vandenbosch, M. (2001). Richness versus parsimony in modeling technology adoption decisions—understanding merchant adoption of a smart card-based payment system. Information systems research, 12(2), 208-222.

Polanyi, M. (1962). Tacit knowing: Its bearing on some problems of philosophy. Reviews of modern physics, 34(4), 601.

Poretski, L., Lanir, J., & Arazy, O. (2018). Normative tensions in shared augmented reality. Proceedings of the ACM on Human-Computer Interaction, 2(CSCW), 1-22.

Poretski, L., Arazy, O., Lanir, J., & Nov, O. (2021). Who owns what? Psychological ownership in shared augmented reality. International Journal of Human-Computer Studies, 150, 102611.

Porter, M. E., & Linde, C. V. D. (1995). Toward a new conception of the environment-competitiveness relationship. Journal of economic perspectives, 9(4), 97-118.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. Administrative science quarterly, 116-145.

Pulakos, E. D., Arad, S., Donovan, M. A., & Plamondon, K. E. (2000). Adaptability in the workplace: development of a taxonomy of adaptive performance. Journal of applied psychology, 85(4), 612.

Purohit, H., Ruan, Y., Fuhry, D., Parthasarathy, S., & Sheth, A. (2012). On the role of social identity and cohesion in characterizing online social communities. arXiv preprint arXiv:1212.0141.

Rai, R. S., & Selnes, F. (2019). Conceptualizing task-technology fit and the effect on adoption–A case study of a digital textbook service. Information & Management, 56(8), 103161.

Roberts, R., & Flin, R. (2020). Unlocking the potential: Understanding the psychological factors that influence technology adoption in the upstream oil and gas industry. SPE Journal, 25(01), 515-528.

Röcker, C. (2010). Why traditional technology acceptance models won't work for future information technologies?. International Journal of Information and Communication Engineering, 4(5), 490-496.

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Rogers, D. L. (2016). The digital transformation playbook: Rethink your business for the digital age. Columbia University Press.

Rowley, J. (2002). Using case studies in research. Management research news, 25(1), 16-27.

Sabelman, E. E., & Lam, R. (2015). The real-life dangers of augmented reality. IEEE Spectrum, 52(7), 48-53.

Sahamir, S. R., Ismail, N. A. A., Rooshdi, R. R. R. M., & Zainordin, Z. M. (2021). Barriers impeding the adoption of Information and Communication Technology (ICT) in construction project management. International Journal of Integrated Engineering, 13(5), 211-219.

Saini, M., Arif, M., & Kulonda, D. J. (2019). Challenges to transferring and sharing of tacit knowledge within a construction supply chain. Construction Innovation, 19(1), 15-33.

Sangshetti, J. N., Deshpande, M., Zaheer, Z., Shinde, D. B., & Arote, R. (2017). Quality by design approach: Regulatory need. Arabian Journal of chemistry, 10, S3412-S3425.

Saunders, M., Lewis, P., & Thornhill, A. (2016). Research Methods for Business Students (7th ed.). Pearson Education Limited.

Schwab, K., & Sala-i-Martín, X. (2016, April). The global competitiveness report 2013–2014: Full data edition. World Economic Forum.

Serrador, P., & Pinto, J. K. (2015). Does Agile work?—A quantitative analysis of agile project success. International journal of project management, 33(5), 1040-1051.

Sisodiya, S. R., Johnson, J. L., & Grégoire, Y. (2013). Inbound open innovation for enhanced performance: Enablers and opportunities. Industrial marketing management, 42(5), 836-849.

Sobhanmanesh, F., Beheshti, A., Nouri, N., Chapparo, N. M., Raj, S., & George, R. A. (2023). A cognitive model for technology adoption. Algorithms, 16(3), 155.

Spreitzer, G. M. (1995). Psychological empowerment in the workplace: Dimensions, measurement, and validation. Academy of management Journal, 38(5), 1442-1465.

Suddaby, R. (2006). From the editors: What grounded theory is not. Academy of management journal, 49(4), 633-642.

Suri, H. (2011). Purposeful sampling in qualitative research synthesis. Qualitative Research Journal, 11(2), 63–75. Symon, G., & Cassell, C. (Eds.). (2012). Qualitative Organizational Research. Core Methods and Current Challenges. SAGE Publications Ltd.

Szulanski, G. (2000). The process of knowledge transfer: A diachronic analysis of stickiness. Organizational behavior and human decision processes, 82(1), 9-27.

Tarhini, A., Hone, K. S., & Liu, X. (2013). Factors affecting students' acceptance of e-learning environments in developing countries: a structural equation modeling approach.

Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). Processes of Technological Innovation. In Lexington, MA: Lexington Books (Issue 3). Lexington Books.

Torre, A. (2008). On the role played by temporary geographical proximity in knowledge transmission. Regional Studies, 42(6), 869–889.

Tsiknakis, M., & Kouroubali, A. (2009). Organizational factors affecting successful adoption of innovative eHealth services: A case study employing the FITT framework. International journal of medical informatics, 78(1), 39-52.

Tverskoi, D., Babu, S., & Gavrilets, S. (2022). The spread of technological innovations: effects of psychology, culture and policy interventions. Royal Society Open Science, 9(6), 211833.

Van Burg, E., Berends, H., & van Raaij, E. M. (2014). Framing and interorganizational knowledge transfer: A process study of collaborative innovation in the aircraft industry. Journal of Management Studies, 51(3), 349–378.

Van Oorschot, J. A., Hofman, E., & Halman, J. I. (2018). A bibliometric review of the innovation adoption literature. Technological Forecasting and Social Change, 134, 1-21.

Velagaleti, R., Burns, P. K., Gill, M., & Prothro, J. (2002). Impact of current good manufacturing practices and emission regulations and guidances on the discharge of pharmaceutical chemicals into the environment from manufacturing, use, and disposal. Environmental Health Perspectives, 110(3), 213-220.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS quarterly, 425-478.

Venkatesh, V., Thong, J. Y., & Xu, X. (2016). Unified theory of acceptance and use of technology: A synthesis and the road ahead. Journal of the association for Information Systems, 17(5), 328-376.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. Decision sciences, 39(2), 273-315.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management science, 46(2), 186-204.

Verbelen, T., Simoens, P., De Turck, F., & Dhoedt, B. (2014). Adaptive deployment and configuration for mobile augmented reality in the cloudlet. Journal of Network and Computer Applications, 41, 206-216.

Wan, W., Liu, L., & Wang, X. (2020). How user-driven innovation and employee intrapreneurship promote platform enterprise performance. Management Decision, 58(12), 2705-2723.

Wang, Z., & Wang, N. (2012). Knowledge sharing, innovation and firm performance. Expert systems with applications, 39(10), 8899-8908.

Wang, Z., Wang, N., & Liang, H. (2014). Knowledge sharing, intellectual capital and firm performance. Management decision, 52(2), 230-258.

Wang, C., & Hu, Q. (2020). Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance. Technovation, 94, 102010.

Wang, H. J., & Lo, J. (2016). Adoption of open government data among government agencies. Government Information Quarterly, 33(1), 80-88.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. Human resource management review, 20(2), 115-131.

Weitzel, J., Pappa, H., Banik, G. M., Barker, A. R., Bladen, E., Chirmule, N., ... & Workman, W. (2021). Understanding quality paradigm shifts in the evolving pharmaceutical landscape: perspectives from the USP quality advisory group. The AAPS Journal, 23, 1-8.

Widiantoro, A. D., & Harnadi, B. (2019, October). Voluntariness Difference in Adoption of E-Learning Technology among University Students. In 2019 23rd International Computer Science and Engineering Conference (ICSEC) (pp. 402-408). IEEE.

Xie, X., Fang, L., & Zeng, S. (2016). Collaborative innovation network and knowledge transfer performance: A fsQCA approach. Journal of business research, 69(11), 5210-5215.

Yuan, Y., Kong, H., Baum, T., Liu, Y., Liu, C., Bu, N., Wang, K., & Yin, Z. (2022). Transformational leadership and trust in leadership impacts on employee commitment. Tourism Review, 77(5), 1385-1399.

Yunis, M., Tarhini, A., & Kassar, A. (2018). The role of ICT and innovation in enhancing organizational performance: The catalysing effect of corporate entrepreneurship. Journal of Business Research, 88, 344-356.

Zhou, T. (2018). Examining user adoption of mobile augmented reality applications. International Journal of E-Adoption (IJEA), 10(2), 37-49.