DIGITAL INNOVATION DIFFUSION - A CASE STUDY OF AN X-REALITY INNOVATION DIFFUSION

Research paper

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Abstract

Digital innovation (DI) has enabled businesses to enhance their existing market offerings by integrating digital features. Despite advanced technologies, substantial marketing efforts, and global recognition, businesses can still struggle to convince customers to adopt their digital market offerings. This process of spreading novel innovation is known as diffusion. In the fast-growing digital world, due to the unique characteristics of DI, traditional diffusion theories and models show limited explanatory power, creating challenges for researchers and practitioners alike. With the aim of exploring these challenges, we position our research within the IS literature with the following research question: "How and why do diffusion enablers and barriers emerge during digital innovation?". We conducted an interpretive case study of Company X, one of the world's largest consulting firms and an active DI practitioner. Our findings suggest that digital innovation diffusion can be enabled or hindered by several understudied interdependencies in its technological architecture. Furthermore, for successful diffusion, how DI distributes the division of labor between actors and subsequent layers must be effectively embedded and aligned for value in the clients' context in order to diffuse successfully. This study provides novel insights and compelling research avenues.

Keywords: Digital Innovation, Diffusion, Layered Modular Architecture, Technological Embedding, Service-Dominant Logic.

1 Introduction

Increasing digitalization has enabled the incorporation of digital capabilities into most everyday objects, with digital businesses now dominating the economy through novel digital innovations (DIs). Digital devices outnumber humans and are seemingly changing everything (Mending et al., 2020), especially how we organize and create innovations (Hund et al., 2021; Nambisan et al. 2017). As a result, contemporary organizations are increasingly relying on digital technologies as cornerstones for strategic value creation (Nambisan 2018).

Recently, research has argued that a traditional industrial innovation logic cannot sufficiently explain the new context of digital innovation, calling for a new digital regime (Lyytinen, 2022). In contrast to other forms of innovation, digital innovation is characterized by distributed processes involving multiple actors and technologies that together co-create novel value. Enabled by "layered modular architectures" (LMAs), different actors create and combine modules within and across layers (*content, service, network, and device*) to create new innovations (Yoo et al. 2010). Networks of actors bring diverse capabilities, knowledge, and motivations for engaging in innovation on these layers, which comes to blur both organizational and product boundaries (Lusch & Nambisan 2015; Hund et al. 2021). Ultimately, digital innovation outcomes manifest as composites made up of modules from distributed actors, which may create complex dependencies (Eaton et al. 2015; Svahn et al., 2017) that can both enable and restrict a focal organization’s efforts toward getting customers to assimilate its new digital products.

Despite rigorous research on digital innovation for over a decade (Tilson et al. 2010; Yoo et al. 2010), little attention has been paid to the outcome of digital innovation (Kohli & Melville 2019). Therefore, our knowledge of what happens after a digital innovation has been developed and entered the market is limited. Fichman et al. (2014) describe this part of the digital innovation process as the stage of diffusion, where the aim of an innovating organization is to enable and persuade a target group to adopt and assimilate the innovation. By addressing this gap in research, our aim is to advance knowledge on the complex sociotechnical dependencies that arise due to the distributed nature of digital innovation processes and outcomes (Hund et al. 2021; Nambisan et al. 2017) and how these may come to enable and constrain the diffusion of digital innovations. To that end, we explore the following research question (RQ): - "*How and why do diffusion enablers and barriers emerge during digital innovation*?"

To address the stated RQ, this study uses an interpretive case study with an in-depth analysis of digital innovation at Company X. Company X is one of the largest consulting companies in the world, with employees partaking in multiple industries and markets as active digital innovation practitioners. We analyze our findings by drawing on the service-dominant logic perspective (Lusch and Nambisan, 2015) and recent work on digital technology embedding (Lyytinen, 2022). Our findings suggest that multiple understudied interdependencies in layered technological architectures can enable or hinder the diffusion of digital innovation diffusion. The findings further show how, for effective diffusion, the distributed development process of all layers needs to be effectively embedded and aligned (albeit some may be beyond direct control) for high resource density and value-in-use in the customers' context. These findings contribute to both novel discoveries and compelling research avenues.

2 Digital Innovation

Building on recent research, we define digital innovation as "*the co-creation of novel value (e.g., product, service, process, or business model) in an inherently distributed and unbounded sociotechnical process through the incorporation of digital technology, forming an innate part of its development, adoption, and diffusion*" (Hund et al. 2021; Nambisan et al. 2017). This definition draws attention to the distributed and unbounded nature of digital innovation and how a need for diverse components and knowledge leads to a lack of predefined innovation agency and the intermixing of different values, goals, and motivations among participating actors (Nambisan et al. 2017). This implies that digital innovation does not unfold in a vacuum (Kohil and Melville 2019) but rather in a complex, dynamic, and uncertain competitive environment where organizational and product boundaries are blurring (Henfridsson et al. 2018; Hund et al. 2021; Svahn & Kristensson 2022). In this environment, orchestration rather than control is key to managing often complex interwoven innovation processes between networks of firms (Mending et al. 2020; Svahn et al. 2017). Digital innovation orchestration supports and shapes the innovation, affecting its co-creation, adoption, and diffusion (Fichman et al. 2014), but requires capabilities to redefine and re-configure the innovation boundaries by reshaping the product ecology (Yoo et al. 2010), which are only limited by the network's (or ecosystems) ability to envision desirable properties and value (Tillson et al. 2010; Hund et al. 2021).

The LMA (Yoo et al. 2010) serves as a useful concept for explaining how complex interdependencies and goal multiplicity may emerge in digital innovation. The LMA of digital technology and subsequent innovation rely on different actors to create and combine loosely coupled modules across architectural layers (*device, network, service, and content*). The modules may have varying degrees of interlinkage, from product-specific to agnostic, which enables (re-)combination of components with minimum regard to other layers without sacrificing cost or quality (Hund et al. 2021; Kallinikos et al. 2013; Yoo et al. 2010). As a result, the LMA increases flexibility by leveraging distributed design resources amongst networks of firms enabled by standardized design interfaces (Yoo et al. 2010; Svahn and Kristensson, 2022, Svahn et al. 2017). A digital innovation based on LMA can therefore be both a stand-alone product and a key component in another digital innovation (Fichman et al. 2014), and similarly, one digital product may serve as a platform for several digital services.

While LMA thus affords flexibility, research has also shown how the innovation processes of applications at the LMA service layer can become dependent and sometimes limited by the ongoing development of underlying platforms (Eaton et al., 2015). These interdependencies caused by the distributed nature of digital innovation imply that what is often promoted for adoption and/or diffusion is never the result of a single firm but also the underlying platform created by a multitude of actors. From this perspective, the challenge for companies engaging in digital innovation lies in orchestrating and producing a combined value offering with only partial control, with layers existing in various degrees of completeness through separate development processes. Therefore, the outcome of digital innovation is dependent on the (re-)combination process of resources and components between networks of firms, individuals, and users in an interdependent layered architecture.

Although digital innovation research has produced significant advances in our knowledge of how and why digital innovation is unique compared to traditional innovation, there are still areas that have received limited attention. While research often emphasizes digital innovation as an unbounded process without a clear beginning or end, limited attention has been paid to when a product (or service) first enters a market. Kohli and Melville (2019) state that there has been a vastly uneven coverage of digital innovation, with only 9% of research investigating digital innovation outcomes. Similarly, Nambisan et al. (2017) state that further research needs to take the unbounded nature between digital innovation outcomes and processes into consideration and build on digital technologies, their characteristics, their architecture (LMA), and modularity not as a mere context but as an active innovation ingredient. Following Fichman et al. (2014), we understand this as a need for better knowledge of the different stages of digital innovation processes and how they come to affect innovation outcomes.

2.1 Digital Innovation Process

While digital innovation has been described as both distributed and unbounded, previous research has found that the process can be understood through sequential stages (or phases) describing an overall focus of innovation activities (e.g., Fichman et al. 2014; Kohli & Melville, 2019; Svahn & Kristensson, 2022). We noted in our analysis of the literature how authors use different terms to signify stages in digital innovation processes, a closer review reveals how they often describe similar actions. Building on this existing work, we provide a synthesized view of these stages following the terms suggested by Fichman et al. (2014).

First, the *discovery* stage concerns the emergence of triggers and describes how these lead to the initiation of digital innovation processes. Triggers can emerge from both internal and external environments, such as opportunities and threats, and hinges on organizational capabilities to detect, assimilate, and apply relevant actions, knowledge- and IT- capabilities to successfully navigate the discovery stage (Fichman et al. 2014; Kohli and Melville 2019; Svahn and Kristensson 2020). The process can also be independently initiated by the release of new digital components or tools (Nambisan 2013). The organizational response can combine the formulation or discovery of new novel ideas or options able to be developed into new market offerings, processes, and business models (Fichman et al. 2014), but it can also be associated with high levels of market uncertainty, making it critical to remain open-minded to recognize future potential (Svahn and Kristensson 2022).

Second, development concerns the stage where the idea, option, or concept is selected, invested in, and further developed into a usable and functioning innovation. This development can take the form of prototypes, market concepts, demonstrations, and more, to later be “packaged” with complementary products or services to form a usable solution for target adopters (Fichman et al. 2014; Svahn and Kristensson 2022). During development, the outcomes can also be “configured” by selecting the features and technologies with which the innovation will be integrated into the adopters' organization with already existing routines, processes, and technologies (Fichman et al. 2014). Such development and integration are partly determined by its technological architecture (Yoo et al., 2010); however, attention must be given to all layers for a successful outcome (Kohli and Melville, 2019). Such attention and decisions affect the absorption of the innovation and if it will require a radical or incremental change to implement or adopt (Fichman et al. 2014).

Third, *diffusion* concerns the period following an initial launch, where a new digital innovation is to be adopted and used by a target group(s). As such, diffusion involves marshaling the necessary resources to diffuse or spread the innovation. For example, Fichman et al. (2014) argue that this stage involves deployment, targeting a group of firms or individuals, enabling, and persuading them to adopt the innovation. If diffusion goes well, they adopt and assimilate the innovation into their daily work and routines. Diffusion is a complex and hard-to-predict phenomenon that can yield vastly different results when integrating the same innovations in different contexts. Considering adoption variables during the development stages, such as industry type, culture, perceived benefits, managerial support, IT-, and IS maturity, environmental factors (organizational standards and visions, fashion, and trends) affect diffusion (and adoption) but goes beyond the normal innovation process (Kohli and Melville, 2019; Wang, 2010). Limited knowledge about future market conditions makes it critical to remain open to recognizing diffusion possibilities beyond the current market offering and to detect opportunities in the external environments to capture value (Svahn and Kristensson, 2022).

Finally, the impact stage of digital innovation involves examining and leveraging the intended and unintended effects of digital innovation on people, groups, markets, and society (Fichman et al., 2014; Kohli and Melville, 2019). Fichman et al. (2014) identify two key activities in this digital innovation phase, value- transformation and appropriation. For the original innovators, value-, transformation, and appropriation involve continuously transforming the technology and organization to take advantage of new opportunities stemming from the new market offering. These activities include governance of intellectual property rights and the complementary products and/or services existing in the innovation ecosystem. But digital innovation impact and exploitation can also be taken advantage of by other organizations by developing their own capabilities through re-combining knowledge, learning, and change (Wang, 2010). Investing in new market offerings have the potential to create new opportunities for digital innovation, new potential for collaboration, and the potential to pursue future opportunities; but it requires organizational flexibility to deploy resources and capabilities to adapt to environmental changes (Kohli and Melville, 2019).

3 Conceptual Framework

In this chapter, we present concepts that helped us understand and explain barriers and enablers for diffusion during our abductive data analysis. First, we drew on recent work by Lyytinen (2022), which suggests that we may understand how digital innovation processes are shaped and justified through three types of digital innovation embedding: *operational, virtual, and contextual*. Second, we leveraged concepts from SDL to explain the value and accessibility of key resources in distributed value creation: *resource liquefaction*, *resource integration*, and *resource density*.

Operational embedding is defined by Lyytinen as when *"digital material is coded and stored physically and run on hardware allowing sensing, recalling, connecting, computing, and display."* (2022, 23). During the innovation process, digital objects (Kallinikos et al. 2013) are coded to execute and operate on a physical device, translating it into real-world organizational operations. This process involves both design and engineering to deploy the digital material in a fast and efficient way, making it accessible, portable, and reliable. Embedding a device in organizational operations involves a social setting and human actors, which in turn creates sociotechnical innovation and design challenges as the outcome needs to be used and manipulated (through inputs and outputs) in a user-friendly way to create value.

Virtual embedding is defined as the *"process of virtualizing real-world phenomena such as assets, actors, activities, and locations into a shared (semiotic) digital representation so that the code can perform on representations"* (Lyytinen 2022, 23). Mapping real-world phenomena and creating digital objects involves both linguistic and social processes to form a digital mirror of the world. The majority of the novelty from digital objects and virtual representations comes from their innate ability to be used in different ways and for different purposes and their continued adaptation and expansion. Virtual representations can only be processed and performed through operational embedding and need to be tied up with outside phenomena to be useful, for example, digital identities tied to real people or GPS coordinates to actual locations.

Contextual embedding is defined as when *"computing is contextualized into an organizational setting where the digital material performs and gives a novel meaning and function for the setting"* (Lyytinen 2022, 23). The performance of any product or service is ultimately connected to a social and concrete setting/context with the involved actors, where the innovation needs to be embedded in meaningful activities to realize value. The performance of the innovation is connected behaviorally to the physical setting and to both operational- and virtual embedding processes, making context embedding reliant on the other layers of the LMA (Yoo et al. 2010). As a result, digital innovation success is related to the different types of embedding and if it is properly contextualized with the hardware/device, context, and combinations thereof at the diffusion phase of innovation (Lyytinen 2022).

While the different forms of embedding described by Lyytinen open up to intimately exploring socio-technical conditions for digital innovation processes, it could not sufficiently explain the relational role of data, content, and other resources that we observed in our data. Therefore, we turned to SDL with its inherent focus on resource integration between many different actors as key to value creation in digital innovation processes. From this perspective, digital products and services are only valuable when they are used by a user in their distinct context (Lusch and Nambisan 2015). As such, firms can never deliver direct value, only offer a value proposition and an invitation to engage in value co-creation with one or multiple actors (Chandler and Vargo 2011; Lusch and Nambisan 2015). Specifically, the concept of *resource liquefaction* refers to the de-coupling of knowledge and information from a physical device to enable its sharing with others and, as a result, enabling it to be used for transforming how work is conducted and enhancing organizational performance. Further, *resource density* refers to the combination of resources and how they are mobilized for a particular situation where the maximum density occurs when the best and most relevant resource combination is mobilized in the most effective and efficient way. *Resource integration* within S-D logic views all actors involved in the innovation process as potential integrators, mainly for two reasons. First, all innovation is the (re-)combination or (re-)bundling of existing resources and innovations, resulting in innovation being unbounded. And second, resources don't hold any value in isolation and need to be combined or co-created with other resources to become useful and valuable (Eggert et al., 2018; Henfridsson et al. 2018; Lusch and Nambisan 2015; Nambisan 2018).

4 Method

We applied a case study approach as our research strategy with the aim of developing rich, detailed insights. The case chosen was an ongoing digital innovation project at one of the top IT consulting firms in the world (henceforth Company X). Company X uses cutting-edge technologies to produce digital products and services for a variety of sectors. The particular innovation process we studied started in 2015 and is focused on developing applications based on X-Reality technology. Since then, Company X has strived to diffuse its DI in different markets. Although these applications have reached high levels of technical performance and have been recognized by digital giants as pioneering innovations based on X-reality, Company X has faced severe challenges in gaining real market traction and adoption beyond limited initial testing and use amongst clients.

4.1 Data Collection and Analysis

The collection of data for this study comprises both primary and secondary data. Primary data was collected through semi-structured interviews (table 1), meeting notes, and observations. We carried out eight semi-structured interviews with seven respondents who all had different key roles in the digital innovation process at Company X. We also conducted an interview with a representative of one of the client organizations. The secondary data comprised press releases, website blogs, brochures, LinkedIn postings, and extensive YouTube videos, which all described Company X's innovation.

Respondent	**Organization**	**Role**	**Duration (mins)**	**Data collection**

1	Company X	Innovation manager	30	Face-to-Face informal conversation and field notes
			80	Semi-Structured Interview
			50	Semi-structured interview on Teams.
2	Client Organization 2	Digitalization Officer	90	Semi-Structured Interview on Teams.
3 & 4	Company X	Developers	120	Face-to-Face, Semi-Structured Interviews and demos.
5	Company X	Senior Consultant and Developer	100	Semi-Structured Interview on Teams.
6	Company X	Developer	110	Semi-Structured Interview on Teams.
7	Company X	Former VP and Innovation Manager	75	Semi-structured interview on Teams.

Table 1. Primary data interview information.

To analyze our data, we followed the three analytic stages suggested by the Gioia Methodology (Magnani and Gioia, 2023). First, we identified first-order respondent-centered codes via an inductive approach. This generated 277 first-order codes, which were finally reduced to 14 1st order inductive concepts (figure 1). Second, we used an abductive approach, where we compared and tested emerging 1st order concepts with existing digital innovation literature in search of concepts helpful in abstracting them to 2nd order themes. Lastly, maintaining our abductive reasoning approach, we drew on the three different types of embedding as suitable aggregated dimensions capable of explaining the key overarching areas in which we identified barriers and enablers to diffusion in our data.

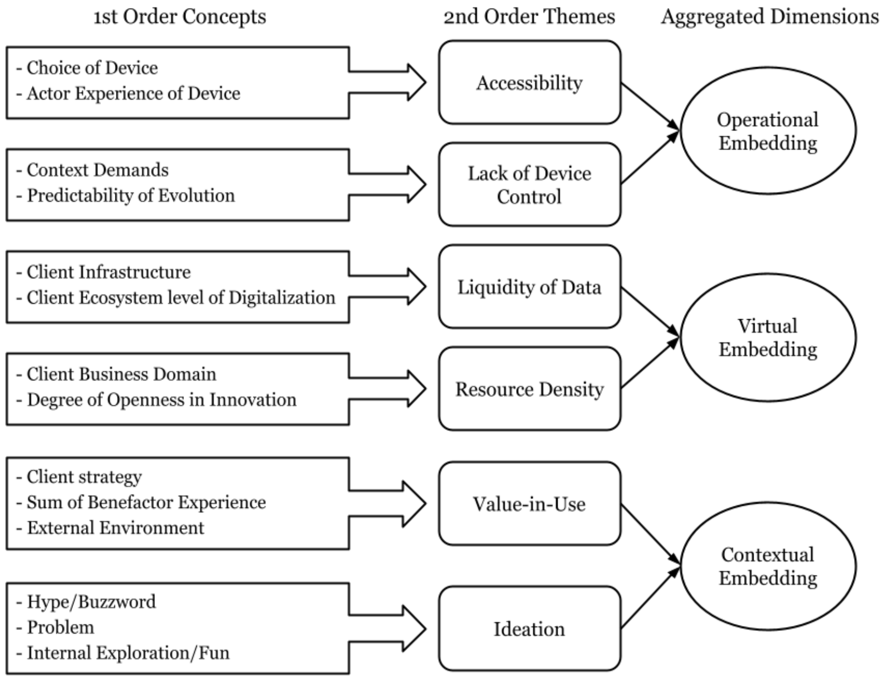

Figure 1. Data Structure.

5 Findings

This section presents an in-depth analysis of our findings organized according to *operational-*, *virtual-* and *contextual* embedding. Figure 2 details a grounded model (Magnani & Gioia, 2023) of Company X's digital innovation process in which arrowheads represent the flow of data (or content) and other components.

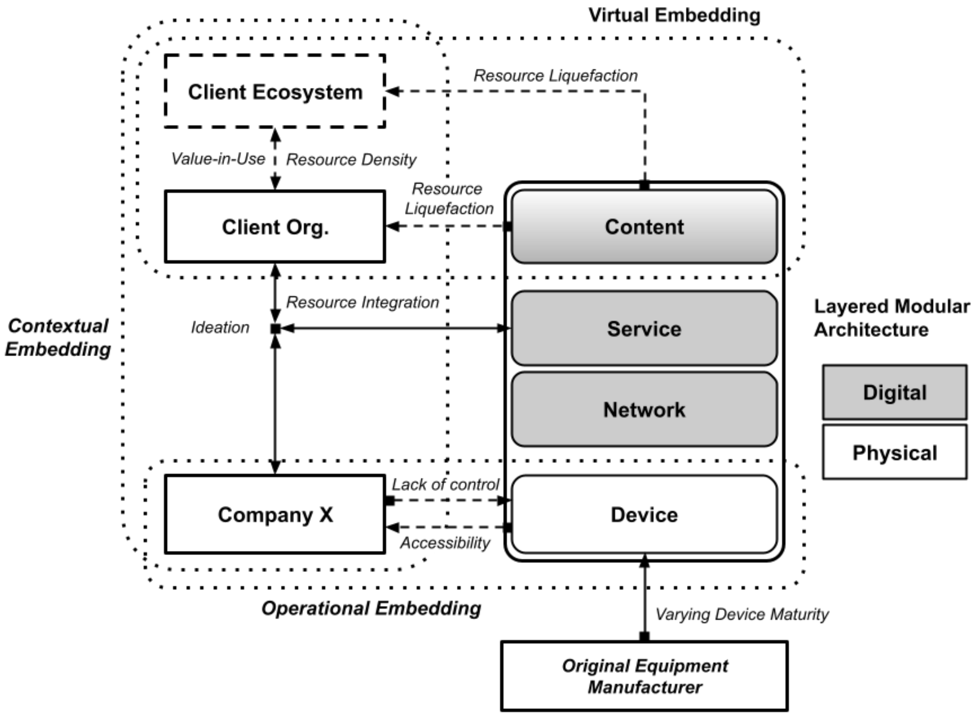

Figure 2. Grounded Model - Company X's Digital Innovation Process for DI diffusion.

As noted, interdependence between components across LMA layers played a key role in the diffusion of Company X's innovation. Acting on the service layer, Company X created cutting-edge applications to meet their client's unique requirements. Meanwhile, the devices on which the innovation operated were controlled by different Original Equipment Manufacturers (OEMs). Further, we noted how clients played a key role in supplying content tailored to their specific requirements and context.

5.1 Operational Embedding

Operational embedding involved Company X selecting a device capable of hosting their application and effectively meeting clients' requirements. This process includes efforts to develop the application in a timely, efficient, and user-friendly manner, assuring the client's accessibility, portability, and dependability. However, as Company X does not manufacture its own device, it actively chooses a device from an external OEM. Our analysis shows that, within this type of embedding, factors of *accessibility* and *lack of control* over the chosen device may severely affect diffusion.

Accessibility refers to the extent that devices hosting the innovation were readily available and familiar to both Company X and their clients. As made evident by our analysis, device accessibility may vary depending on its level of maturity. Highly mature devices tend to have a higher degree of general adoption, and, as a result, a larger number of people have experience using them for clearer use cases. Respondent 1 highlights the importance of considering varying maturity levels when choosing devices since it influences how easily the innovation can be diffused.

> "[...]*moving it from headsets too, let's say, smartphones, which is a more mature product in itself in a more mature platform, [...] we can always see that using the technology approach in our innovation on smartphones is a bit of a different story because it makes more sense for people to use it nowadays. That technology is in a stage where the headset*

> *isn't. [...] A lot of people aren't used to using augmented reality on their phones either if they haven't played Pokémon Go [...] or pushing furniture around in your apartment with the IKEA app, that could also give you an advantage in using AR technology on a smartphone"* - Respondent 1

The difference between AR headsets and smartphones illustrates the difference between the two devices available for innovation. Smartphones are widely adopted and have a large user base with a long experience of using the device, which facilitates user acceptance of new innovations on that device. This indicates that mature devices may be more beneficial to stimulating digital innovation diffusion. Respondent 5 mentioned that certain XR devices are less mature and, as a result, have poor quality, excessive weight, and high costs, which may also hinder adoption. These limitations create barriers to the widespread acceptance and utilization of such devices for digital innovations.

> *"The problem with augmented reality right now is that it's prototype style also for the hardware, we have glasses that are sort of lowest or low quality for what we want, and the weight is like almost like a kilo, [...], and the price is like €.X which is way above what we want,"* - Respondent 5

Respondent 5 points out that a device's accessibility relates to its cost, weight, and overall development. Other respondents have mentioned that different devices have more established users, norms, routines, and use knowledge, which affect learning, adoption, and diffusion. Based on our research, it is clear that device maturity and previous experience with a device can act as both enablers and barriers for operational embedding and subsequent diffusion, thus warranting a strategic choice of a device when orchestrating service-level digital innovation.

Lack of control refers to the lack of influence that Company X experienced over the evolution of devices provided by OEMs. Our analysis suggests that Company X's influence over devices was limited, and despite their DI being showcased on prominent technology stages and winning awards, they were not able to engage OEMs in the DI process. As a result, operational embedding became, to a large extent, dependent on an unforeseeable evolution of OEM devices, which influenced the extent to which the innovation could be diffused.

> *"as a developer, mostly you don't have the manpower to develop glasses, you're always a little bit depending on what glasses are out there [...] Instead of having some eyeglasses, you can just develop on the smartphone. But I said it just depends on the manufacturers and on the scenarios."* - Respondent 6.

Respondent 6 (and others) underlined this dependence on OEMs and the uncertainties associated with operational embedding when the future development of devices is difficult to predict. Since innovation outcomes could not be fully tested in client contexts, it became difficult to fully assure a satisfying user experience. As our analysis showed, different clients operate within their own unique contexts where innovation is going to be embedded, used, and realized, which in turn places different demands on the innovation.

> *"The whole HoloLens is a good technology, but depending on your IT skills or IT knowledge, and of course, it's not [waterproof]. You can't stand in [City] in pouring rain with the HoloLens."* -Respondent 7

The respondent's answers clarify how both use- and client contexts pose unique demands, for example, waterproofness when used outside or different lighting options suited for indoor/outdoor use.

In all, our analysis thus shows how *Accessibility* and the *Lack of Device Control* heavily influence operational embedding during DI and in turn, DI diffusion. While a highly accessible device (e.g., smartphone) may facilitate both development and adoption due to high levels of prior experience in both the development and use context, a less accessible device (e.g., VR headset) comes with technical capabilities and use expectations that are often unclear. When each client context poses unique demands, matching requirements with features becomes challenging. Further, a lack of control over devices implies maintained uncertainty regarding if and when they will change to either enable or hinder an application's intended features.

5.2 Virtual Embedding

When developing an XR application for a target client, Company X needs to virtualize and embed the client's resources, e.g., the physical environment or goods within it. This virtualization of assets into digital content needs to reflect the real world to provide practical value correctly. Through our analysis, we identified two key factors that influence the process of virtual embedding and the subsequent diffusion of digital innovation. First, the *liquidity of data* in both the client's organization and their ecosystem refer to the availability and accessibility of data and content, which influences the potential for resource integration during the digital innovation process. Second, we found that *resource density*, i.e., the extent to which accessible data can be combined to produce value, depends both on how difficult the client's business domain is to virtualize and the degree of openness in the innovation process.

In order to gain *liquid data*, Company X must virtualize clients' physical resources from their physical form and convert them into digital data or content. As expressed by Company X's client, this process depends heavily on the ability of clients to contribute by making resources available, which in turn depends on their technological maturity and infrastructure.

> *"But then we needed to provide all of the things, all of the content, apart from the technology [...] and because I'm a digital [professional], I to some extent, understand what they're talking about with the programs they use and so on. [...] I've been very involved, even though I just ordered a product".* - Client organization.

While some clients may possess the digital skills necessary, respondents also expressed how it was often more challenging to attain liquid data from clients with low digital maturity. Further, our analysis shows that to achieve high resource density, the level of digitalization in a client's ecosystem also plays a major role in resource liquefaction and subsequent integration.

> *"If I have a client with high IT maturity, they probably would have gotten a long way themselves, often involving partners [...]. But I mean, it creates a higher potential to have an external party involved in the innovation process. So, higher IT maturity, the likelihood of IT industry contacts which is all also higher and therefore the involvement of other parties, that's how I view it."* - Respondent 5.

As respondents pointed out, actors in the ecosystem of clients (e.g., their customers and partners) and how they collect data are vital for resource liquefaction. Therefore, the client's ability to orchestrate its own data liquefaction amongst actors in its own ecosystem is often key to digital innovation.

In essence, the analysis shows that to contribute with liquefied data and act as active resource integrators for co-creation, the digitalization level (infrastructure, IT maturity, knowledge, and capabilities) of the client and their ecosystem is vital. Since Company X does not go directly to the customer's partners, the client is responsible for resource liquefaction and ecosystem integration. As such, the client's ability to orchestrate their ecosystem, infrastructure, and IT maturity determines their ability to co-create an innovation outcome that is relevant to their real-world context. As a result, the client's and ecosystem's infrastructure and digital/tech maturity can be both enablers and barriers for digital innovation diffusion; where clients with higher maturity have an easier time creating an accurate and relevant digital mirror of their context and contributing it to the DI process, thus assisting in assimilating and diffusing digital innovations. This shows how Company X can never deliver value, only offer a value proposition and invitation for co-creating, which depends on the client's infrastructure and digitalization to liquefy data and contribute as active resource integrators.

While resource liquefaction concerns producing and accessing potentially useful data, *resource density* referred to getting data of quality and quantity sufficient to virtualize client environments effectively and accurately. As our analysis revealed, different clients operated in different business domains, bringing their own unique demands. Different business domains acted as either enablers or barriers for digital innovation diffusion; for example, respondent 5 mentions how laws and regulations hinder device usage in one context.

> *"We have one issue, which is because of regulations, and we cannot use head-mounted displays on a driver [...] So for now, until we are at the stage where it's not distracting, the driver is forbidden from using it."* - Respondent 5.

Similarly, other respondents also mentioned how applications relying on accessible city infrastructure data could not be used once it is protected by counter-terrorism laws. On the other hand, other domains may be easier to virtualize due to a preexisting excess of useable digital data. As with gaining resource liquefaction, the key to attaining resource density in virtual embedding is also having openness in the innovation process. As expressed by the respondent below, resources from external organizations were occasionally brought in to increase resource density.

> *"[...] because they were really good at doing GPS, small prototypes. So, they're involved in that one [...]. And in the later stage of the project, we actually tested with real industrial GPS, but that's another story when we shifted from HoloLens to iPads to adapt."* - Respondent 7.

Although most development was done in-house, external resources and capabilities were brought to gain specific functionalities. In all, our analysis thus shows how both *data liquidity* and *resource density* influence virtual embedding, which in turn may enable or constrain digital innovation diffusion. Specifically, the degree of data liquidity may depend on the degree of digital maturity amongst clients and their ecosystem, but also the ability of clients to orchestrate actors within their ecosystem to produce data and make it available. In terms of resource density, we see how contextual demands both may enable and inhibit the use of data, but we also note how openness in the digital innovation process may untap the synergy potential of multiple actors, resources, and capabilities.

5.3 Contextual Embedding

Contextual embedding concerns Company X embedding their application into the setting and operations of their clients and ensuring that it provides meaningful value therein. Our analysis shows that success in contextual embedding depends on attaining *value-in-use* and managing expectations that result from the *ideation* process.

Value-in-use draws focus to how users experience using Company X's applications in actual use contexts. As previously mentioned, Company X has faced challenges with getting clients to actually use and assimilate its digital innovation into everyday business and operations. As our analysis shows, a first step towards positive value-in-use may be having a clear strategic intent with the innovation. Multiple respondents mentioned the importance of clients having a clear strategy for their future use of the application, but also for how they could develop it over time.

> *"[Client Organization] is a very good example where we have done strategizing and stuff for the future* [...] *their intention from the very beginning was that we want to have this really cool [innovation] but wanted to continue [...], but usually, we don't have a client that is really looking that much forward in the future."* - Respondent 4.

As further expressed by informants, the strategic vision for digital innovation needs to be shared across the organization so that partners, customers, and particularly management work towards the same strategic trajectory. As Respondent 3 points out, management often serves as a gatekeeper to diffusion.

> *"And as far as we know, they've all been happy with it. But I think it's more like the people higher up are all like, no, don't think this is worth the investment."*- Respondent 3.

Ideation concerned the process through which the scope of digital innovation projects evolved over time. Our analysis shows that for Company X, ideation could initiate in several ways with different preconditions, and this, in the end, influenced their ability to diffuse the innovation. One example was ideation initiated by the hype around emerging technology, which happened after the public release of a new XR headset. Following the release, clients turned to Company X with ambitious requests without knowing the true capability or capacity of the new technology.

> *"The other hurdle is, as I said, people not understanding what the technology is and the actual use cases for them because they want XR and an app that doesn't need to be XR or they want some data AI Implementation is like they are buzzword type things, and they don't really understand."*- Respondent 3.

Chasing hype affects the innovation process and the outcome, where the hyped technology might not live up to the client's expectations due to its low maturity. However, as expressed by informants, actual assimilation of the hyped technology may be secondary to some clients who seek to portray themselves as innovative rather than to gain actual value out of the technology.

Other examples of ideation initiation included internal experimentation and the intentional search for solutions to existing client problems.

> *"A lot of clients have been coming to us asking us if can we solve this?* [...] *Sometimes, we have an idea that we want to achieve or try out, and then we see clients that might be interested in it, and other times they come to us with a problem or just out of curiosity. [...] So on our own time, we explored the technology itself, but in every client conversation, we explored it together with them and sought to find the pain point [...]."* - Respondent 1.

Our analysis shows that different forms of ideation matter in terms of establishing and managing expectations, and ultimately, they provide different conditions for attaining value-in-use. Hype-initiated processes may lead to unrealistic expectations that are difficult to meet by using immature technologies, which leads to a lack of diffusion. On the other hand, ideation initiated by an established problem or pain point is likely to foster clearer and more realistic expectations. Conclusively, we found that *Value-in-use* and *ideation* are key to successful contextual embedding during digital innovation and that they, in turn, may both enable and constrain diffusion. Without a clear client strategy and good value-in-use experiences, which are dependent on the external environment, the innovation won't diffuse into the client's organization. How the digital innovation process is initiated or ideated, in turn, affects the expectation of the outcome, even if the end goal is to use the outcome or not. Our analysis shows that clients with a clear strategy initiating the digital innovation process have a clear value-in-use and subsequent expectations for the innovation, which greatly helps contextual embedding and diffusion. For example, if the digital innovation process is initiated by hype and buzzwords, then it becomes hard to manage expectations and, subsequently, the value-in-use experience of the beneficiary, thus hindering contextual embedding and DI diffusion.

6 Discussion

The aim of this study is to generate in-depth knowledge to address the identified research gaps relating to digital innovation diffusion and, in the process, answer our RQ: -*" How and why do diffusion enablers and barriers emerge during digital innovation?"*. Contributing to research, our data analysis answers our RQ by identifying novel interrelations between both the involved distributed actors and the different architectural layers developed during a digital innovation process. Our analysis shows how actions during the process may give rise to specific diffusion barriers and enablers. We now turn to discuss these findings in relation to this study's related research.

6.1 Barriers and Enablers to Digital Innovation Diffusion

First, our analysis shows how operational embedding is dependent on an OEM-provided device layer and highlights the barriers and enablers that Company X encounters in controlling and accessing this layer. The integration of digital content into physical systems is known as operational embedding, and in this case, several factors contribute to effective operational embedding. The device's maturity level, as well as Company X's control and accessibility over the device layer, are shown to be essential factors. A mature device has undergone substantial development, making it more stable, dependable, and compatible with a wide range of users. This eliminates the possibility of compatibility issues and performance constraints when attempting to align it with the client's requirements and context. However, when successful DI diffusion depends on the maturity level of the device, this becomes a barrier. Since

Company X is not a hardware developer, their lack of control over the device layer puts them at a disadvantage in meeting client context demands. Owing to the reprogrammable nature (Yoo et al. 2010) of DI, Company X can select any accessible device in the market aligning with specific client needs (if it exists), thus requiring a strategic choice for successful digital innovation diffusion.

Second, virtual embedding is the process of integrating real-life events into a shared digital representation. In our study, the analysis shows that the process of virtual embedding happens through resource liquefaction, which results in value-in-use and resource density subject to the client and their ecosystem. The ecosystem may include a network of collaborators, stakeholders, and other actors who share knowledge and contribute to resource density. As shown in Figure 2, virtual embedding happens at the content layer, where resources are liquified between the client and their environment and added to the LMA via Company X; a process known as resource integration. Our analysis shows that the level of digitalization has a direct impact on virtual embedding, where clients with high digital maturity has an easier time contributing, leading to a greater diffusion rate with a high value-in-use. As a result, DI diffusion is influenced by the client and their ecosystem's digital maturity.

Finally, Contextual embedding is the process of integrating digital devices in an organizational environment in a way that aligns with the environment's specific needs and operations. As shown in Figure 2, it encompasses both virtual embedding and operational embedding. Contextual embedding considers the client ecosystem for value-in-use and resource density, understanding its significance in the wider environment in which the innovation is diffused. The importance of first ideation in this process cannot be overstated. A variety of reasons and actors can trigger DI, and these factors have a considerable impact on the outcome. External factors, such as clients and their ecosystems, often chase hype and buzzwords without fully understanding the true capabilities and capacities of the technology. Adding to that, each client has different contextual requirements and value propositions, making it challenging for Company X to integrate resources into the LMA. To overcome this barrier, clear communication is essential, as is identifying and understanding the specific contextual conditions that the innovation aims to address. Also, identifying key actors and managing their expectations becomes crucial for successful contextual embedding.

In essence, clients with an understanding of the value that digital innovation can bring, as well as effective problem identification, are critical for aligning the innovation with its operational context. Clients that have sufficient resources and infrastructure, as well as a well-defined strategy for starting the digital innovation process, have better knowledge of the value-in-use and future expectations connected with the innovation. These insights contextualize the process of contextual embedding and diffusion. On the one hand, hype-driven ideation starting the digital innovation process motivated by buzzwords rather than a clear knowledge of its capabilities can be a barrier leading to unfounded expectations and challenges. While on the other hand, clear goals and future strategies for the DI outcome facilitate the digital innovation co-creation and subsequent diffusion.

6.2 Digital Innovation Logic

The barriers and enablers to diffusion as well as insights regarding how and why they emerge have wider implications for IS research on digital innovation. First, the findings in this study shine new light on the unbounded and open-ended nature of digital innovation (Henfridsson et al., 2018; Svahn et al. 2017), breaking down borders between processes, actors, and organizations unfolding in a nonlinear fashion across space, and time (Kohli and Melville, 2019; Nambisan et al. 2017). Mending et al. (2022) emphasize this point by stating that it is increasingly impractical to separate the process from its outcome since it can become a part-, and spawn other innovation processes blurring where one process begins and ends. However, such descriptions may be theoretically conceptualizable, but when viewing digital innovation through a process perspective in practice with a focus on its outcome and diffusion, such preconceptions become problematic. In contrast to earlier conceptualizations, this empirical study shows that the digital innovation process has identifiable stages (*discovery, development, diffusion, and impact*). While these findings support earlier research of Fichman et al. (2014), they also extend the scope of the IS field by empirically showing how and why each stage is intertwined with the distributed actors, such as the OEM, Client, Company X, and Ecosystems ultimately affecting the DI process, outcome, and diffusion. Although the process is shown to exist in various degrees of unbounded and open-ended, our research suggests that the DI outcome can clearly be understood as existing in a constant state of flux; constantly being reassigned to new meanings, becoming parts of other DI processes, and sparking innovation. This supports the notion by Nambisan et al. (2017) and Hunt et al. (2021), that it is increasingly impractical to separate the digital innovation process from its outcome, not only because of social actors (re-)assigning meanings and values; but because of the outcome and impact of one DI can greatly affect the diffusion of another when used as a modular LMA component(s) as shown in this study.

As previously mentioned, little attention has been paid to digital innovation outcome and diffusion (Kohli and Melville, 2019), where existing research views it as a largely separate stage that requires marshaling the necessary resources to diffuse or spread the innovation (Fichman et al. 2014). Our research stands in contrast to such views and instead shows that to understand DI diffusion, the entire process from discovery to impact needs to be considered; even the evolution of external DI processes if they are to be selected as components (or modules) as a part of the LMA. This point refers to the distributed, intertwined, and dynamic nature of the DI process and outcome since the continued evolution of all included LMA layers, features, and properties in a new market offering affect its value and diffusion - and are not in the hand of a single actor.

Digital innovation has, since its early conceptualization with the LMA, been described as reducing complexity and increasing flexibility between layers and components with varying degrees of interchange without sacrificing cost or quality (Kallinikos et al., 2013; Yoo et al., 2010). Within IS literature, this is also referred to as modularity enabling distributed design amongst distributed networks of firms (Hund et al. 2021), emphasizing the re-combination and orchestration of components with minimum regard to other layers (Henfridsson et al. 2018; Yoo et al. 2010). While these conceptualizations can be good for understanding the phenomena of digital innovation and its widespread effects, they show large variations in practice. This study shows a contradictory view with strong- and multiple interdependencies between the device-, service-, network-, and content layers to reach high resource density and value-in-use for diffusion. Eaton et al. (2017) study shows similar interdependencies between the LMA service layer and underlying platform, which are replicated in this study, but with additional interdependencies between the device layer and the rest of the layered architecture. These findings are in line with Kohli and Melville (2019), where attention must be given to all layers for successful outcomes but add how and why enablers and barriers for DI diffusion emerge in an empirical case study with the rest of the LMA. Finally, these findings are empirically in line with Nambisan et al. (2017) statement about how the innovation scope can be hard to understand for any single firm due to the blurring and spanning of LMA boundaries between distributed firms. As such, this study shows how DI diffusion is dependent on the underlying LMA layers/platforms, shining a light on the challenge of orchestrating a combined (LMA-)value offering with high resource density and value-in-use for a target group(s) context - with only partial layer control.

6.3 Limitations and Suggestions for Future Research

From our literature of the Senior Scholars' list of Premier Journals and to the best of our knowledge, this is the first study empirically investigating digital innovation diffusion from an architectural standpoint. However, we see how the findings of this study could have been different with different research strategies and choices along the way. First, this study uses a single case study limited to Company X and one of their clients, where we used triangulation of historical data concerning a multitude of (XR-)innovation processes with different outcomes as the basis for our analysis. We see how this study results could have been different if more client data from different organizations had been collected to compare further Company X's own views on their innovation process and how their clients, in turn, experienced the co-created outcome. For example, we see how to further insight could have been gained by interviewing clients who choose not to adopt and diffuse their co-created innovation; and further analyze if the "failed" clients would agree with our findings, testing if our model has predictive power over DI diffusion. Similar lines of reflection can be made for a multi-case study including more organizations suffering from the same phenomena, which we see could generate greater insights and generalizability into how DI's distributed nature affects its outcome and diffusion. We further see how Company X might be a unique study context due to XR innovations, which we reflect might be different from other "types" digital innovations due to its heavy reliance on the virtual embedding of the clients' context for value-in-use. Lastly, the notion that LMA increases flexibility and reduces complexity (Yoo et al. 2010) might be fitting for theoretical generalization. However, as our study suggests, such is not the case in diffusion practice. Future studies should, therefore, explore additional interdependencies between different architectural layers for DI process diffusion with additional enablers and barriers for better novel digital innovations outcomes. Such studies could build on this study's findings and, through cumulative effort, create a body of knowledge explaining how the distributed co-creation of DI affects its outcome.

7 Conclusion

Despite a decade of study on digital innovation, little attention has been given in the IS literature to digital innovation outcomes and how its distributed development affects diffusion and adoption. With this research question: "*Why do diffusion enablers and barriers emerge during digital innovation?*" we explored the reasons behind the emergence of enablers and challenges during digital innovation diffusion. We conducted an interpretive case study utilizing qualitative data and analysis to answer our research question. We performed eight semi-structured interviews with company X's digital innovation managers, developers, and one client. We also gathered information via observations, field notes, and secondary sources. Our data analysis shows how digital innovation diffusion can be enabled or hindered by multiple unexplored aspects of the distributed co-creation of a layered modular architecture, where all layers need to be "aligned" or successfully embedded (some beyond control) for high resource density and value-in-use in the clients' context for successful diffusion. Further, our study shows why resource density and value-in-use are dependent on the level of digitalization of the clients and their ecosystems, influencing the ability to participate as active co-creators with resource liquefaction and resource integration of data, content, and domain-specific context. Finally, our study shows that "who and why" the innovation process was ideated matters in terms of development strategy, absorptive capacity, expectations, and experience of the innovation outcome and, thus, its potential diffusion.

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