Transforming Digital Inventions into Digital Innovations – A Missing Material Perspective on Technology Adoption

Friedrich Chasin
University of Cologne
fc@ercis.de

Abayomi Baiyere
Copenhagen Business School
aba.digi@cbs.dk

Abstract

Technology agnosticism dominates explanations of technology adoption in digital innovation. Accordingly, technology itself plays a limited role in determining adoption success. Instead, aspects outside the inventors' control, including marketing, user perceptions, and organizational environment, decide the adoption outcome. We revisit the original innovation concept and draw attention to what we call a digital invention. Looking at the transition of a digital invention to digital innovation, we argue for a technology-affinity perspective to complement existing adoption perspectives. The new perspective emphasizes the role of conscious invention design for innovation. We find three ways in which specific invention focus can increase the invention's chances for adoption. For instance, we show that contrary to the prevalent idea of technologies enabling new ways of doing things, it is the invention's focus on enabling innate behaviors that can facilitate adoption. Past innovation and contemporary innovation in the film industry illustrate our thinking.

1. Innateness over artificiality

Should technology enable us to do new things in a new way – an idea that continuously circulates the discourse of IS academics and practitioners – or should technology capitalize upon what we already know how to do and translate it into new capabilities? To explore this question, we suggest examining a recent case of a technological invention that made headlines: When *Mandalorian* TV series – a science fiction saga within the Star Wars cinematic universe about the adventures of an interstellar bounty hunter and his transformation towards a loving guardian of an unlikely companion – were first released in 2019, the production became an instant success. The series received acclaim from both critics and audience and became a symbol of success for the media and entertainment conglomerate *Disney* that owns the show. According to the series creators, much of the success could be attributed to the technological inventions that were rapidly adopted during the production [1]: The cornerstone of these inventions was the so-called "*Volume*" – a 270-degree curved 20-foot-high video wall made up of 1,326 LED screens and an LED ceiling. The *Volume* enabled the show producers to place over 3,000 square feet filming set inside a dome, in which a mix of digital imagery and computer-generated content that was illuminated from the LEDs was creating unique and shooting-ready visual environments inside a stationary studio place (note the photorealistic backgrounds projected inside the *Volume* including sky, mountains, and artificial constructions in Figure 1). Being limited only to the creators' imagination, these sceneries then represented a nexus of the set routines that were re-aligned according to the *Volume* capabilities.

Figure 1 Sets virtually co-created in the *Volume* in real-time enabling actors interact with the environment and operators to capture visuals that are close to final © Disney 2020.

The '*Mandalorian*' filming method differed from how cinematic material is conventionally captured in

URI: https://hdl.handle.net/10125/80123
978-0-9981331-5-7

HICSS

similar moving picture projects. The latter relies on post-production of video material filmed against a green screen and requires actors to interact with imaginary objects in imaginary environments. In the words of Richard Bluff who was the show's visual effects supervisor "green screens confuse both actors and crew, limiting spontaneity and on-the-fly creativity" [1].

The *Volume* invention changed the filming experience: Various members of the organization, including actors, directors, and camera operators, expressed high level of *Volume* acceptance [1]. In addition, the set members highlighted their sudden technology-enabled ability to fall back to routines that were 'natural' and intuitive to them (and in that being innate to them) instead of performing artificial routines mandated by the post-production-reliant technologies traditionally used on sets. For instance, actors were able to interact with objects brought to life by the *Volume,* and the directors and camera operators were working with (and adjusting to) the concert of actors, set requisites, and *Volume*-produced imagery instead of imagining elements that would be added during the post-production[1]. These benefits led to adoption of the *Volume* by the filming crew during the first installation of the show and were manifested in the show producers' decision to continue the *Volume*-driven shift from post-production to pre-production activities for the second show season.

The above case of a successful adoption of digital invention can be positioned within the extensive body of knowledge in IS research on digital innovations and technology adoption. Characteristic for the major part of this research is the premise that material aspects of the technology – that is, its attributes – are mediated by a plethora of social processes [2]. According to this view, inferring unmediated change from attributes of the technology is challenging [3]. In fact, against the background of the popularity of social constructivism in IS research, highlighting the importance of technology use instead of its material characteristics [4] can still be seen as part of the IS research and teaching mainstream.

The IS discipline's focus on detaching adoption from the material aspects of the technology has enabled the emergence of an extensive body of knowledge that can explain multifaceted applications of the same technologies depending on the organizational context. For instance, the adoption has been explained in terms of the effects of marketing instruments [5], user perceptions [6], or institutional processes [7]. However, the link between the material design of technological inventions and their subsequent adoption (leading to innovations) has not yet been subject to academic scrutiny. As a result, while the importance of material aspects of inventions is not explicitly denied in the innovation literature, and inventions are recognized as the substance around which innovations emerge [31], [32], we know little about mechanisms through which invention characteristics can facilitate innovation. Despite the material view in IS literature and calls to employ it [3], it has not yet been utilized to understand the adoption of digital inventions. Therefore, we ask the question, *how do material aspects of a digital invention influence its transition to a digital innovation?*

We address the question by examining which purposefully introduced material characteristics of digital inventions support its transition to innovation hence providing a necessary condition for the traditional explanatory views on technology adoption to take effect. In that, we highlight the complementarity of our views to prior research. Our theorizing is based on reviewing past transitions of inventions towards innovations and is enriched through the illustrative case of the *Volume* invention introduced above, which is based on the behind-the-scenes interviews with the senior members of the filming crew. In our approach, we rely on iterative reflections upon accumulated experience in addressing digital innovation.

Our main contribution is in drawing attention to digital inventions and their material aspects, which help to reinforce the material perspective on digital innovation. Our going back to digital inventions as the subject of what IS research traditionally treats as given emphasizes a complementary view on, and represents an essential component in, the emergence of digital innovations [8]–[10]. Specifically, we capture a relationship between digital innovation challenges and aspects, which represent the material focus of inventions and can enable adoption fostering mechanisms. For instance, we find that contrary to the narrative often observed in the academic and professional discourse that successful technological inventions enable new ways of doing things, it is the ability of a technology to going back to old way of doing things (enabling known or 'innate' user behaviors) that drives the adoption of an invention. The practical implications of our work are manifold, enabling organizations to engage with a conscious invention design for innovation.

This manuscript is structured as follows. The next section provides background on invention and innovation. This is followed by the introduction of the *five I(s)* model, which explains the transformation of digital inventions to digital innovations. To support the

[1] See the illustration of the changed set routines in a video offered by one of the technology providers for the show - ILM https://www.youtube.com/watch?v=gUnxzVOs3rk

model, we review past innovations in light of the model in section five. The examples include, in addition to the introductory example of the *Mandalorian*'s *Volume*, the IS innovations brought through *Apple*'s *iPhone* and *Nintendo*'s *Wii* inventions. Finally, we conclude the paper with a discussion of limitations and avenues for further research in section six.

2. Conceptual background

2.1 Inventions and innovations

The relationship between invention and innovation is long established in fields such as innovation management. However, the relationship between these two concepts has not transferred to their "digital" equivalent despite drawing from the same ontological foundations. Generally, an invention – typically characterized by its originality, novelty, and underlying creativity – is not an innovation until it has been adopted by users or the market [11] , [16]. This highlights the fact that there is a transition from invention to innovation. While creating a novel solution or an artifact may be an invention, becoming an innovation encompasses much more than the created solution/artifact in itself to include the associated process involved in successfully adopting the invention. Hence, the difference between innovation and invention lies in that innovation provides economic value and is diffused to other parties beyond the inventors [12]. This distinction is important because an invention only becomes a successful innovation through parallel, directed interactions among organizational, development, design, and market aspects [13]. As Roberts (2007) aptly puts it, innovation equals invention plus exploitation [14].

Indeed, inventions and innovations have been used interchangeably as if they were synonyms, particularly when the invention sense is implied. In most usage of these terms, innovation tends to be used as an umbrella term that captures both. This popular parlance seems to have seeped into the IS literature to characterize how the field views the relationship between digital inventions and digital innovations in its vocabulary.

2.2. Digital invention and digital innovation

Although the emerging digital innovation literature in IS acknowledges the materiality of the innovations [14], the invention roots that precede the innovation seem to be largely silent in these literature [10], [15]. There is an implicit assumption that if a digital invention is made, it would automatically set foot on the adoption path because of its features. However, recent examples like *GoogleGlass* have shown that having an invention that wows the audience and is revolutionary in terms of its technological features does not necessarily imply that it would make the transition to becoming adopted [16] – which is a prerequisite for an invention to be qualified as an innovation.

Although *digital* innovation is a logical extension of the innovation concept from innovation management, the digital innovation concept in IS seems to be detached from its traditional innovation foundation in relation to (digital) invention. Digital invention, which we define as *a novel creation (solution or artifact) that leverages digital technologies as an intrinsic component and fulfills a particular objective or need,* has remained largely undefined and absent in IS studies. In fact, it is surprising that a search through all the basket of 8 journals and the whole AIS library returns only two fleeting mentions of digital invention. We offer two interrelated explanations.

This detachment can be explained by a) the fact that the transition in the innovation vocabulary in IS comes from the prior conceptualization of innovation as a customer-facing output (e.g., products), and by b) the prior conceptualization of IT innovation in IS, which focuses on internal IT-related innovations [8]. The foundation of digital innovations in IT innovation allows for the thinking that now dominates part of the digital innovation literature. Within this thinking is the implicit assumption that when an innovation is created, it would naturally become subject to adoption by virtue of its functionalities and its value. This aligns with a large proportion of the literature in this area looking at IT innovation within organizational contexts where the users have limited options to opt out of adopting the technology. The latter is reflected in the language (e.g., user resistance) used to describe occasions where the users (e.g., employees) fail to adopt advances in IT technologies.

This view from the IT innovation roots of the concept seems to have seeped into the scholarship of digital innovations so much so that rarely do we see an account of customer-facing digital innovations from a material or inventor's perspective that seem to have considered the adoption beyond creating the innovation to fulfill a particular objective/functional feature. Yet, this IT innovation-based assumption is limited in digital innovation contexts where innovations are no longer mostly internal IT innovations but are increasingly more customer-facing or represent a re-definition of an organization's value proposition [9], [17]–[19]. In contrast to internally focused innovations where users may have limited options and are almost coerced to adopt new digital inventions, with external customers, there are typically several alternatives from which to pick. This showcases the need to reorient our thinking about digital innovations from the dominant IT innovation-based assumptions of adoption.

Within this view of innovation captured by digital innovation, the foundational relationship between innovation and invention becomes salient. We position the objective of this paper within this issue in prior literature. In particular, a return to inventions - digital inventions in our context - brings to the fore the material aspects of an invention and highlights the process of creating innovation. Such a focus allows for an investigation of the inner workings of the novel (re)combination of digital technologies [14], [20] to create new solutions or artifacts that did not exist before. We specifically focus on the material considerations that could explain why a digital invention can become adopted and thereby transition from being just a digital invention to becoming a digital innovation. Following [21], we take a perspective of digital innovation and digital invention as an *outcome* perspective rather than as a *process* perspective [14], [17], [18].

3. Invention focus as an adoption driver

3.1. Building blocks for digital invention adoption

The basis for our understanding of the relationship between inventions and innovations is the interplay emerging when *invention's foci* address *innovation challenges* and trigger *mechanisms that foster invention adoption* (Figure 3).

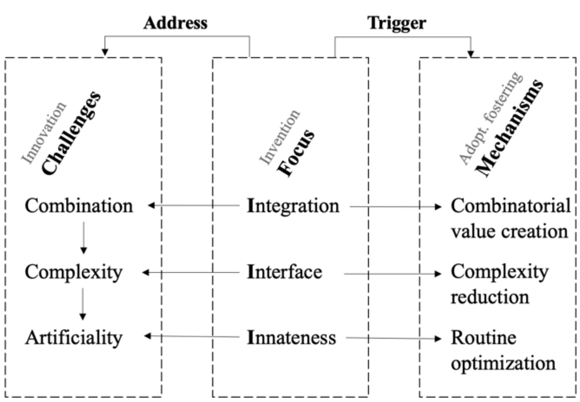

Figure 2. Interplay of innovation challenges, invention foci and adoption fostering mechanisms.

In what follows, we discuss how three distinct invention foci can help to transition to adoption fostering mechanisms. We integrate *Mandalorian*'s *Volume* at the end of each block of the interplay in form of extended vignettes to better illustrate our thinking. The vignettes are based on the insights from interviews with the producers, directors, and actors of the series [1].

***Integration** - from combination challenge to combinatorial value creation:* The growing portfolio of available digital technologies creates opportunities for combining them into value-generating digital inventions [32]-[34]. However, organizations not only strive to capitalize on opportunities but are often driven by the need to find solutions, for which no dedicated solutions exist. In fact, with the growing range of available technological solutions for recurring problems, the remaining problems are shifting in nature towards being more complex and requiring a combination of existing digital technologies instead of reinventing readily available parts of a missing invention. As the opportunity space grows in size and the problem space grows in complexity, so grows the *combination challenge* for inventors, that is, to identify the right technologies for combination and the right way to combine them. Like "too many cooks can spoil the broth," too many available technologies can spoil the invention. The challenge can manifest itself in a plenitude of ways. For instance, analysis paralysis, choice overload, or decision fatigue are few examples of how inventing can be hampered against the backdrop of technologies growing in number, ambiguity, and sophistication [22].

To address the challenge, inventions can focus on seamless and synergetic *integration* of invention components within the boundaries imposed by the organizational context. Whether the search for the technology combination candidates is motivated by promising opportunities or dictated by day-to-day challenges, the increase in the *combinatorial value* of a unique combination of two or more individual digital technologies working in concert is the ultimate goal of the integration. The dynamism in the value of individual technologies [23] is inherited by the combination-driven inventions and hence forces inventors to repeatedly reassess the value space of a particular technology combination as the value of individual technologies changes with time. This highlights the importance of combination trialability in a sense similar to trialability in the diffusion of innovation [24], yet in connection to how easy it is to prototype the combination from the technical rather than organizational viewpoint.

Extended vignette 1

In *Mandalorian*'s *Volume*, the focus on technology *integration* was driven less by exploring the opportunity space. Instead, "necessity was the mother of invention" (Jon Favreau, show creator): Time and budget limitations of a television series met the ambition to produce visuals of a full-featured film, which left Jon wondering about "how do you take advantage of all [available] technologies" to reach this goal given the constraints. The *combination challenge* is well-captured by the evolution of the digital infrastructure used on the set. First attempts to approach the unique combination of technologies around *Volume* went back to producer's experiments while working at Disney's Jungle Book (2016) and Lion King (2019) moving pictures. Although the first experiments lacked sophistication, they represented a proof-of-concept. For instance, on the Lion King set, a puppet head of a lion was placed in front of a TV set and, equipped with a motion-tracking from Virtual Reality (VR) technology, changed the position of the camera (that was facing the head and the TV set in the background) was captured, fed back to the screen, and thus represented a similar case of a hybrid digital and virtual environment that could be captured.

Eventually, the gradual change in the technologies, specifically with LED video walls becoming larger, pixel pitch improving, and the technology becoming cheaper, the unique combination of the same technologies on a larger scope enabled the invention of the *Volume* as a set of integrated technologies including video walls, game engine, and VR "combined in the way nobody has done it before" (Jon Favreau). The high availability of the technologies facilitated experimentation with the Volume technologies, none of which were proprietary, enabling fast and cheap emulation of various technology combination permutations. The synergies between individual technologies led to high *combinatorial value creation*. An anecdote by the show's executive producer, Dave Filoni, illustrates the *Volume*'s unique value that transcends the value of the individual technologies it integrates: "We were doing this talk (that) was being sent to Disney people at the Disney conference. We have two director's chairs set up in this hangar. We were talking and this whole thing was going on […] in the *Volume*. And later we found out [that] nobody realized we were in the *Volume*. They thought they were looking at this giant set they spent all their money on" [1].

Interface *- from complexity to complexity reduction*: Creating invention by means of technology combination adds to the potential *complexity* of the invention from the user perspective. When left unattended during the invention design, the complexity represents an adoption barrier and, with that, an innovation challenge as users are required to possess knowledge of the individual technologies and operational know-how. The resulting difficulty to operate an invention has been a long focus of the IS discipline in the context of the behavioral analysis of the technology acceptance, captured most prominently by the perceived ease of its use concept (see TAM [25] and its manifold reincarnations). While the importance of increasing technology usability is omnipresent in the IS literature, we approach it from the material perspective and emphasize the link between invention attributes and invention usability. In that, we depart from the technology acceptance thinking and focus on the characteristics of the technology itself instead of it's perception.

The complexity of the invention can be hidden from the user behind the *interface* layer. We recognize the diversity of interfaces that can include graphical user interfaces (GUI) and physical interfaces [14]. For instance, a terminal for self-service flight check-in at an airport represents an interface with both GUI and physical components, each of which is relevant in its role of hiding complexity. We note that our view of interface role is complementary to how IS has been conceptualizing interfaces, e.g., to provide faithful representations of reality [26]. The goal of the invention's focus on interface is to reduce interactions required for activating value-generating processes offered by individual digital invention components. The interface focus triggers *complexity reduction* as a mechanism that fosters invention adoption by enabling users' easier comprehension of the system functions and limiting the user input to initiating procedures that do not require further user intervention.

Extended vignette 2

The *Mandalorian*'s *Volume* is a prime example of the *complexity* challenge emerging from the integration of manifold technologies in three categories. First, *Volume* integrates *high-resolution digital photography*, *motion capture* (mix of software and hardware for capturing human motions through sensors and translating the signals into a digital model), and *motion builder* (software for creating digital characters and animating them using physics models) technologies that generate content for the virtual environment. Second, there is a *video game engine* that integrates the generated content together with further elements created in the game engine internally for rendering the virtual environment in real-time. Third, the content rendered by the game engine can then be either accessed via computer screens or VR headsets to explore the scenes. The game engine output can be projected on the *LED video wall panels*. *Motion capture* technology used in *VR* and attached to the cameras controls which parts of the virtual environment are projected onto the video wall through moving and changing the facing of the camera.

Despite the complexity of the overall technological mix, the user interaction with the technology on the set is limited to the *interface* represented by the video wall and the motion-tracked cameras. Everything else is either part of the preparation by individual departments and professionals or happens automatically, like in the game engine real-time rendering of the parts of the virtual environment that the camera is pointing at. Hence, the complexity of the technological mix is hidden behind the *Volume*'s interface and triggers *complexity reduction* in the invention's operation and increases its usability for the directors, camera operators, and actors on the set.

***Innateness** - from artificiality to routine optimization:* being a product of the combination and complexity challenges, inventions can require users to interact with them in an artificial or counterintuitive way. This can happen either through artificiality in the direct interaction with the material layer of the invention or through the routines enforced through the use of the invention. The direct artificiality can be observed when the invention requires a detailed manual for operation or user's knowledge or experience from operating other inventions that were artificial in use. On the other hand, indirect artificiality can be observed when routines known and previously employed by the users are interrupted in the way that they require additional or alternative actions outside the direct engagement with the invention. Invention can focus on *innateness*, that is, on enabling users to tap into the pool of innate routines and behaviors instead of requiring them to learn new ones. Innateness of a behavior is a comparative measure and separates behaviors and routines learnt at a young age or through repetition from other behaviors and routines. It is the behavior that is preferred by a user given a choice among alternative behaviors. It is the spontaneous choice and the fallback option for doing something against time pressure. The focus on *innateness* enables intuitive user behaviors, which eventually leads to *optimization of routines* on the individual and organizational levels. The optimization can be achieved across various dimensions, including time and quality. However, we argue that users would prefer an innate behavior even if the latter would require more time to complete or yield an inferior quality output. Given this preference, the focus on innateness increases the invention's chances for adoption.

Extended vignette 3

Artificiality is a challenge well-captured in technologies that preceded *Mandalorian*'s *Volume*. For Carl Wearhers, one of the leading actors in the show, working with green screens was "so disorienting because usually, as an actor, you are standing there, and you are pretending". When asked about his feelings about working with green screens and reshoots from a director's perspective, Rick Famuyiwa replied: "I am strapped in by [technology]". Capturing an acting performance is a powerful example in this context as good acting aims to appear "natural" to a viewer. Doing it with technologies that require you to overcome confusion and disorientation does not help the case.

However, *Volume's* focus on *innateness* was arguable a by-product – an unintended attribute of an invention. While striving for managing time and budget pressure, producers of the show created an alternative to expensive set building, yet it was not the show owners, but the "actors [who] had one of the biggest responses to this whole thing" (Dave Filoni, executive producer). For instance, the actor Giancarlo Esposito has been recorded embracing the *Volume* because "now, we have a room where there are things that you can see, where I can climb up on top of my [ship] and see the horizon. It is interactive! I can now feel the power of that sun coming up […], I have something concrete and physical to look at, and feel, and touch. Wow, what a difference!". A similar sentiment was expressed by directors like Rick Famuyiwa who earlier signaled his frustration with green-screen technologies saying that the *Volume* "put me back [in the director's chair] where the rules are what you understand".

The innateness focus impacted more than just directors, camera operators, and actors. When taking stock of how the film operation changed while shooting the first season, the show's animation director, Hal Hickel, made an incredibly pertinent observation: "We talk about the *Volume* as being this super cutting edge means of film-making, which it is, but one of the great things about it is how it enables different departments to work in a more traditional way". The 'traditional way' in the *Mandalorian*'s case represented *routine optimizations*. The executive producer, Kathleen Kennedy, recalls: "[*Volume*] allows you to go into the cutting room the next day or even sometimes that day, look at it and pop right back in and pick up something you might have missed very easily". Furthermore, directors had the opportunity to get involved much earlier than you normally would on a television show. They were combined with their crew and their editors, and together they would come up with a first cut of the show using a 'virtual cinema'. Because of that, organizational routines rather shifted from post-production to pre-production activities.

When positioning the effects described above in the context of invention transition to innovations, the three invention foci can be seen as moderating effects on the adoption (*five I(s)* model in Figure 3). The model manifests the material view on adoption emphasizing the effect of the technology on the innovation in contrast and in addition to the prior research that is rooted in the technology agnostic view on the translation of invention to innovations. The model is complementary in that it can be seen as the first step in the invention's journey towards innovation. We argue that lack of invention focus on innateness, interface, and integration results in the invention's disability to become innovation despite social processes that have been previously well-captured by the marketing, behavioral sciences, and organizational literature.

3.2. The five I(s) model: transitioning from digital invention to digital innovation

We argued that coming up with a digital invention calls attention to the creativity and ability to *integrate* disparate technologies (combination challenge), develop *interfaces* that simplify/hide underlying technological complexity, and embrace *innateness* features that unlock users' intuitive engagement with the invention leading to routine optimization. These form the core of the *five I(s) model* that we propose in what follows. Our thesis is that these three attributes that exhibit stronger technology affinity can explain the adoption potential of an invention. In particular, we highlight the importance of the *innateness* attribute as an essential consideration that is oft-ignored. Finally, we contrast our proposal with the dominant technology-agnostic perspective in prior literature on the adoption and diffusion of an invention.

While the literature in fields including marketing, organization science, and behavioral sciences have provided ample knowledge to explain the adoption of inventions, they have taken a dominant technology-agnostic perspective. In such views, the technology could be replaced by carrots or biochemicals, and the recommendations would remain largely the same. For example, marketing takes an important position in the push by organizations to get their inventions adopted in the marketplace [5]. This is a sensible technology-agnostic view of the antecedents or mediators of adoption from a market perspective. Similarly, other strands of research emphasize the behavioral attributes of the adopting entity as the prerequisites for an invention's adoption – for example, the perception-focused orientation of TAM [6]. While these technology-agnostic views are useful, we posit that black-boxing technology misses out on the fine-grained nuances that the distinction in the composition of digital inventions offers. This is particularly pertinent in a digital technology context where the generativity [14] and the potential for recombination e.g., SMACIT [33] open up a new vista and choice for responding to innovation challenges. With digital technology's fluid and dynamic character, we argue that it has become pressing and important that scholarship unveils the essence of the technology matter in the invention to innovation story.

With Figure 4, we unpack the backbox of digital invention to showcase the positioning of the three highlighted attributes (integration, interface, and innateness) in the invention's transition to digital innovation. Given that these attributes, as explained earlier, represent the link between the innovation challenges and the adoption fostering mechanism, we suggest that they would play a crucial role in determining the propensity of a digital invention becoming a digital innovation. In particular, we consider them to serve as a mediator on the technology-affinity path of the invention to innovation transition.

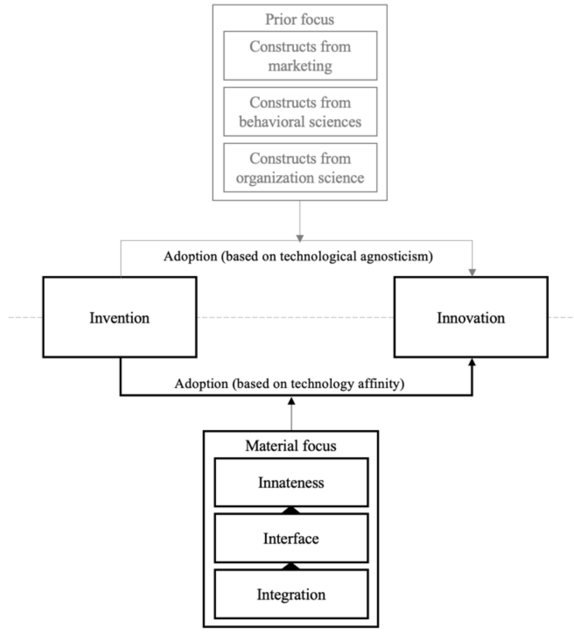

Figure 3. The five I(s) model.

We propose that *the adoption of a digital invention is dependent on how well the invention's three Is (integration, interface, and innateness) attributes satisfy the adoption fostering mechanisms (i.e., combinatorial value creation, complexity reduction and intuitiveness) – contingent on the input of the technology-agnostic pathway.* This essentially implies that the input of the creator of a digital invention towards its propensity to transition to a digital innovation, lies in attending to the three I(s) representing the invention focus.

Among the three I(s), the innateness attribute stands out. This becomes vivid in the illustrative cases we provide. While most studies on digital invention allude to the import of the integration and interface attributes (i.e., combinatorial value creation and complexity reduction), incorporating the invention's capacity to unlock the innate nature of the users is largely missing [8], [14], [15]. If all else is equal, the propensity for an invention to foster adoption via innateness can make the difference. While many digital inventions are highly qualified in terms of their combinatorial value and complexity reduction, little effort seem to be given to making these inventions enable the users to follow their natural and intuitive ways – rather many inventions require the users to learn new, and many times unintuitive or natural, workaround loops in order to extract the intended value from the inventions. We suggest that this can be a distinguishing factor in the adoption of two competing inventions. Hence, we posit that innateness is a central component in our theorizing as it also underscores that we do not subscribe to a technology deterministic view of the world. Our message at its core recognizes and advocates for activating the action potential [27] for users to exercise agency in ways innate to them. As we would demonstrate later, these hold important implications for future research, particularly in design science research [28].

We note that our argument does not present one pathway (technology agnostic versus technology affinity) as having primacy over the other. On the contrary, our message is that both pathways hold value in explaining how a digital invention becomes a digital innovation – hence the contingency in our proposition. Thus, our work should be seen as a long due addition to prior views rather than a replacement. To be clear, while our presentation may appear as an extreme interpretation of prior literature, we do acknowledge that some scholars (in IS and innovation management) have attended to the technology aspect of digital inventions (typically labeled digital innovations [9], [14] in different forms. However, the treatment of the digital technology component of digital inventions in these prior studies have taken a perspective in which an invention is seen as the creation of novel solutions to a problem/opportunity and the emphasis is on the features of the solution with little emphasis on *how the digital invention transitions to an innovation or what attributes of the invention enables the transition.* It is this specific void in prior literature that our paper is positioned to fill.

4. Past innovations in light of five I(s) model

Looking at successful innovations of the past yields support for our thinking. *Apple's iPhone*, and *Nintendo's Wii* are two past inventions that can be viewed as examples of adoption influenced by the material characteristics of the underlying technologies. The heterogeneity of these inventions in terms of market and purpose highlights the utility of the technology affinity perspective we are offering as a complementary explanation of the technology adoption. In what follows, we reconstruct the *iPhone*'s journey from **i**nvention to **i**nnovation by looking at the *iPhone*'s initial focus on **i**ntegration, **i**nterface, and **i**nnateness. The results are then summarized together with the case of *Nintendo's Wii* in Table 1.

The first generation of *Apple's iPhone* was introduced in 2007. Although the technologies used in the *iPhone* existed in other mobile devices at the time of invention, it was the unique combination resulting from the technology integration that arguably made the difference. Specifically, a state-of-the-art camera, a widescreen, fast internet communication module, stand-alone applications, and a touchscreen were integrated into a single device (see Figure 5). Individual technologies existed not only outside the market for mobile phones but even were present in previous phone devices like in the cases of a touchscreen in the *IBM's Simon* (1992), phone camera in the *Kyocera's Visual Phone VP-210* (1999), or phone internet connection, for instance in *Motorola*'s products (2001). Yet, similar to *Mandalorian's Volume*, the sophistication of the individual technologies and the corresponding change in their respective individual value enabled *Apple* to find the fitting time, the fitting combination, and the fitting way to integrate these technologies. This was one of the foci of the *iPhone* as an invention, and a high combinatorial value of the product was the result.

Figure 4. Hardware components of the first-generation iPhone, artwork by GRID (https://gridstudio.cc).

Utilizing its innovative interface, *iPhone* focused on eliminating artificiality in the experience of using a phone where a telegraph-like pressing three times a certain button to create a 'c' character used to be considered a norm. Instead, *iPhone* users could tap into innate behaviors like touching and swiping known to them since childhood. The latter is a reason behind the success of touchscreen-based devices among young people with various accounts of children operating smartphones, like in the case of a 14-months toddler going rogue and buying a car with the parent's smartphone [29].

Table 1. Cases of inventions becoming innovations.

Apple's *iPhone* as **Invention:** A mobile phone product released in 2008. The phone was envisioned as the first 'true' smartphone.		
Integration: Focus on integrating state-of-the-art hardware technologies, including a touchscreen and a dedicated operating system with stand-alone applications as software.	**Interface**: Focus on using the touchscreen to hide the complexity of the underlying hardware and software technologies representing a unified interface for user interaction.	**Innateness**: Focus on enabling users to operate the device more intuitively than with other phones of that time by touching and swiping the content displayed on a touchscreen.
iPhone as **Innovation:** Adoption of the phone by millions of users and acquisition of the cult character serving as a launchpad for creating a line of products that continue the success of the first product until this day.		

Nintendo's *Wii* as **Invention**: A game console developed in 2006. It was envisioned as a new gaming experience instead of competing with other game consoles in terms of performance and realism in the visuals.		
Integration: Focus on integrating video game technologies, Bluetooth, and gyro sensor technologies.	**Interface**: Focus on using a motion controller to hide the complexity of video game interactions.	**Innateness**: Focus on enabling users to imitate known or natural movements instead of learning artificial controls.
Wii as **Innovation**: Despite some backlashes following manifold accidents resulting from playing the console, Wii was a success with over 100 million units sold and now standing for a generation of motion-controlled entertainment devices.		

5. Concluding Discussion

The dominant technology-agnostic view of prior literature leaves us a limited theoretical and practical guidance for organizations attempting to develop digital inventions. Yet, this is becoming a pressing concern and an item of strategic importance on the agenda of many organizations as they embark on a digital transformation journey to remain competitive in a digital age [30]. The challenge for such organizations who may have expertise in a non-digital domain is about creating the digital invention and enable its transition to a digital innovation. Our *five I(s)* model provides a useful conceptual toolkit for navigating the transition from digital inventions to digital innovations.

With the *five I(s)* model, we highlight the importance of the material aspects of a digital invention and how these could foster the adoption required for the invention's transition to digital innovation. Our thinking represents a departure from the dominant view in prior literature [6] that tends to elevate other aspects (e.g., behavioral, marketing, institutional) over the material or technology-focused considerations of invention adoption.

Our work holds important implications for related research areas such as design science research (DSR). DSR scholars are uniquely positioned to create artifacts that qualify as digital inventions [28]. The *five I(s)* provide design considerations for such scholars as they juggle with novelty while addressing innovation challenges. DSR has been positioned as a paradigm that provides an avenue for applied management research that may find value in unpacking the digital invention's material considerations that can increase its propensity to become a digital innovation.

The digital invention perspective that we bring to the burgeoning digital innovation discussion [14] holds implications for how we theorize about adoption [3]. Specifically, it calls for sensitivity in the implicit assumption that a digital invention is subject to adoption by virtue of the inherent value that it promises. Our work calls attention to how the integration, interface, and innateness of the invention focus matter in the adoption. We also note that with everything being equal, the innateness of an invention holds an important position in determining the propensity of transitioning to an innovation. While prior literature has contributed foundational knowledge to the 5Is [31]-[34], we suggest that the innateness that we elevate in this paper holds explanatory power for illuminating the transition of a digital invention to a digital innovation. Our paper brings to the fore and opens up opportunities for further research on this dimension. We note that our perspective does not nullify the accumulated knowledge from the technology-agnostic perspective. Instead, the material perspective helps to understand adoption scenarios where the focus on invention's integration, interface, and innateness guides digital invention's transition to digital innovation.

References

[1] Disney, "Disney Gallery / Star Wars: The Mandalorian," 2020.

[2] P. M. Leonardi and S. R. Barley, "Materiality and Change: Challenges to Building Better Theory about Technology and Organizing," Inf. Organ., vol. 18, no. 3, pp. 159–176, 2008.

[3] J. Kallinikos, P. M. Leonardi, and B. A. Nardi, "The Challenges of Materiality: Origins, Scope, and

Propsects BT - Materiality and Organizing: Social Interaction in a Technological World," Mater. Organ. Soc. Interact. a Technol. World, no. 1, pp. 1–21, 2012.

[4] K. Grint and S. Woolgar, The Machine at Work: Technology, Work and Organization. Wiley, 1997.

[5] H. S. Makkonen and W. J. Johnston, "Innovation Adoption and Diffusion in Business-to-Business Marketing," J. Bus. Ind. Mark., vol. 29, no. 4, pp. 324–331, 2014.

[6] V. Viswanath, "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model," Inf. Syst. Res., vol. 11, no. 4, pp. 342–365, 2000.

[7] E. B. Swanson and N. C. Ramiller, "The Organizing Vision in Information Systems Innovation," Organ. Sci., vol. 8, no. 5, pp. 458–474, 1997, doi: 10.1287/orsc.8.5.458.

[8] R. Kohli and N. P. Melville, "Digital Innovation: A Review and Synthesis," Inf. Syst. J., 2019.

[9] S. Nambisan, K. Lyytinen, A. Majchrzak, and M. Song, "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," MIS Q., vol. 41, no. 1, 2017.

[10] F. Svahn, L. Mathiassen, and R. Lindgren, "Embracing Digital Innovation in Incumbent Firms: How Volvo Cars Managed Competing Concerns," MIS Q. Manag. Inf. Syst., vol. 41, no. 1, pp. 239–253, 2017.

[11] J. Verloop and J. G. Wissema, Insight in Innovation: Managing Innovation by Understanding the Laws of Innovation. 2004.

[12] R. Garcia and R. Calantone, "A Critical Look at Technological Innovation Typology and Innovativeness Terminology: A Literature Review," J. Prod. Innov. Manag., vol. 19, no. 2, pp. 110–132, 2002.

[13] K. Shaista, M. Tomasz, and B. Boaz, "From Invention to Innovation: Toward Developing an Integrated Innovation Model for Biotech Firms," J. Prod. Innov. Manag., vol. 23, no. 6, pp. 528–540, 2006.

[14] Y. Yoo, O. Henfridsson, and K. Lyytinen, "Research Commentary - The New Organizing Logic of Digital Innovation," Inf. Syst. Res., vol. 21, no. 4, pp. 724–735, 2010.

[15] A. Baiyere, H. Salmela, and T. Tapanainen, “Digital Transformation and the New Logics of Business Process Management,” Eur. J. Inf. Syst., vol. 29, no. 3, pp. 238–259, 2020.[16] A. Klein, C. Sørensen, A. S. de Freitas, C. D. Pedron, and S. Elaluf-Calderwood, "Understanding Controversies in Digital Platform Innovation Processes: The Google Glass Case," Technol. Forecast. Soc. Change, vol. 152, p. 119883, 2020.

[16] A. Baiyere, (2015). Adoption-A core attribute of a Disruptive Innovation. In ISPIM Innovation Symposium

[17] J. Lee and N. Berente, "Digital Innovation and the Division of Innovative Labor: Digital Controls in the Automotive Industry," Organ. Sci., vol. 23, no. 5, pp. 1428–1447, 2012.

[18] K. Lyytinen, Y. Yoo, and R. J. Boland, "Digital Product Innovation Within Four Classes of Innovation Networks," Inf. Syst. J., vol. 26, no. 1, pp. 47–75, 2016.

[19] R. G. Fichman, B. L. Dos Santos, and Z. Zheng, "Digital Innovation as a Fundamental and Powerful Concept in the Information Systems Curriculum," MIS Q. Manag. Inf. Syst., vol. 38, no. 2, pp. 329–343, 2014.

[20] P. Hukal and O. Henfridsson, "Digital Innovation – A Definition and Integrated Perspective," in The Routledge Companion to Management Information Systems, 2017, pp. 360–369.

[21] M. M. Crossan and M. Apaydin, "A Multi-dimensional Framework of Organizational Innovation: A Systematic Review of the Literature," J. Manag. Stud., vol. 47, no. 6, pp. 1154–1191, 2010.

[22] Longo, C., & Baiyere, A. (2021). So, what should I watch? Choice overload among SVOD users. In ISPIM Conference Proceedings

[22] J. Kallinikos, A. Aaltonen, and A. Marton, "The Ambivalent Ontology of Digital Artifacts," MIS Q., vol. 37, no. 2, pp. 357–370, 2013.

[23] O. Henfridsson, J. Nandhakumar, H. Scarbrough, and N. S. Panourgias, "Recombination in the Open-ended Value Landscape of Digital Innovation," Inf. Organ., vol. 28, pp. 89–100, 2018.

[24] E. M. Rogers, Diffusion of Innovations. Free Press, 1995.

[25] F. D. Davis, "A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results," 1985.

[26] Y. Wand and R. Weber, "On the Deep Structure of Information Systems," Inf. Syst. J., vol. 5, no. 3, pp. 203–223, 1995.

[27] O. Volkoff and D. M. Strong, "Critical Realism and Affordances: Theorizing IT-associated Organizational Change Processes," MIS Q. Manag. Inf. Syst., vol. 37, no. 3, pp. 819–834, 2013.

[28] R. Baskerville, A. Baiyere, S. Gregor, A. Hevner, and M. Rossi, "Design Science Research Contributions: Finding a Balance between Artifact and Theory," J. Assoc. Inf. Syst., vol. 19, no. 5, pp. 358–376, 2018.

[29] S. Rosenbaum, "Baby Buys Car on eBay Using Her Dad's Phone," NBC News, 2013.

[30] L. Wessel, A. Baiyere, R. Ologeanu-Taddei, J. Cha, and T. B. Jensen, "Unpacking the Difference Between Digital Transformation and IT-enabled Organizational Transformation," J. Assoc. Inf. Syst., vol. 22, no. 1, pp. 102–129, 2021.

[31] T. W. Malone, K. Crowston, J. Lee, and B. Pentland, "Tools for Inventing Organizations: Toward a Handbook of Organizational Processes," IEEE, 1993.

[32] A. Baiyere, and H. Salmela, "Wicked yet Empowering-When IT Innovations are also Disruptive Innovations", ICIS Forth Worth

[33] Sebastian, I. M., Ross, J. W., Beath, C., Mocker, M., Moloney, K. G., & Fonstad, N. O. (2017). How Big Old Companies Navigate Digital Transformation. MIS Quarterly Executive, 16(3), 6.

[34] Lyytinen K., Rose G. (2003), "The Disruptive Nature of Information Technology Innovations: The Case of Internet Computing in Systems Development Organizations", MISQ, 27,4, pp. 557-595